MACHINERY.

September, 1903.

THE CURTIS STEAM TURBINE AND ITS MANUFACTURE.

Fig. 1. General View of General Electric Works, Schenectady, from Mount Pleasant.

THE most important development in steam engine work since the time of George H. Corliss has been the advance in steam turbine building during the past ten years; and probably the most interesting step in this development has been the advent of the General Electric Co. in the steam turbine field. De Laval and Parsons had both experimented extensively in their native lands before their products were introduced into this country and when the Westinghouse Machine Company began to build Parsons turbines it was not looked upon as out of the ordinary, for that wheel was well known and the Westinghouse Company had manufactured steam engines for many years.

The General Electric Company, however, have confined themselves almost entirely to electrical machinery and the fact that they have prepared for the manufacture of a steam turbine, as yet but little tried and almost unknown, on a more extensive scale, if we are not mistaken, than any of their competitors, here or abroad, has aroused no little interest and speculation.

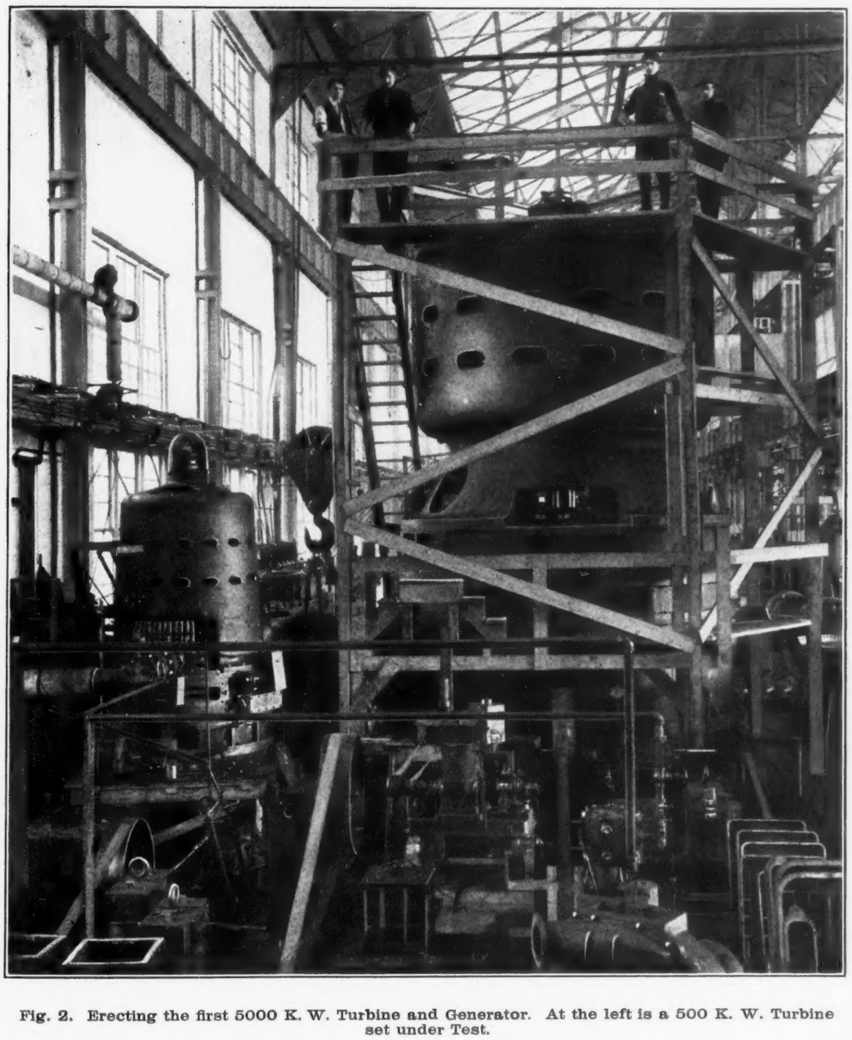


Fig. 2. Erecting the first 5000 K. W. Turbine and Generator. At the left is a 500 K. W. Turbine set under Test.

The first illustration on this page is a view of the General Electric Company's works, Schenectady, N. Y., taken from Mt. Pleasant, an elevation some distance to the rear of the plant. Most of the buildings are situated at the right of the center of the engraving. The largest one, near the center, is the main machine shop, which is one of the largest in the country, and the one at the center, a building 750 feet long by 150 feet wide, is a new structure devoted entirely to turbine manufacture. At the left, where the ground is seen to be broken, a new and larger building is now going up, which will be used for the manufacture of turbines, and as orders are ahead for 240,000 kilowatts of turbine units, it is anticipated that both structures may be needed to accommodate this remarkable business.

The second illustration shows the first 5,000-kilowatt turbine (6,700 horse power), direct-connected to its generator, in process of erection, and beside it a 500-kilowatt machine. The larger turbine was shipped to Chicago, and is one of several to be installed at the Commonwealth Electric station in that city. Compared with the vertical reciprocating engines of like capacity in the station of the Manhattan Railway Company, New York City, the turbine is, of course, very much smaller. It weighs about one-eighth as much, and one of this size can ordinarily be erected, ready to run, in four or five weeks, while the reciprocating engine is liable to require more than that number of months. The turbine is designed to operate at 500 revolutions per minute and the vertical engine at 75 revolutions per minute. In point of economy the turbine will undoubtedly be greatly superior with fluctuating loads, since one important advantage of steam turbines is that the steam passing through them is not subject to alternate heating and cooling, as in the engine cylinder, and so it makes little difference in the slight loss from condensation whether much or little steam is pass-

ing through. It is expected that the variation in efficiency in this machine will not be more than three per cent. from half load to 50 per cent. overload. It is also expected that its regular economy will be better than that of its big competitor, for, granted that the passages through the turbine are correctly proportioned, expansion can be carried much further than in the steam engine. Steam at condenser pressure occupies a great deal of space and to provide for complete expansion in a steam engine the low-pressure cylinder must be impracticably large. There is also the great and irrecoverable loss due to condensation and re-evaporation in the steam engine which is entirely absent in the turbine.

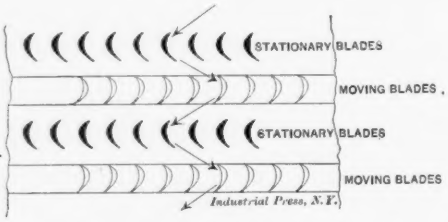


Fig. 3. Diagram of Parsons Turbine.

In Fig. 5 is a reproduction from a photograph of the 5,000 kilowatt machine. It is of vertical type with generator mounted above the turbine, the axis of each being vertical. One of the compound turbine wheels of this machine is shown in Fig. 6 and in Fig. 7 is shown one of the first Curtis turbines built, a 500 kilowatt horizontal machine, which has been running successfully for two years in the power house of the General Electric Company's works. The turbine wheels are arranged in two sets in casings, one on each side of the exhaust pipe appearing prominently in the illustration, and the generator is located at the right.

Before proceeding with further explanation of the Curtis turbine, it will be advisable to outline the general principles of the steam turbine in general, as a type of machine, and then explain the Curtis method of solving the problem. In any steam motor, provision must be made to expand the steam from boiler pressure down to atmospheric or condenser pressure, as the case may be, in order to utilize the full power of the steam. The method of doing this in the steam engine is too well known to need explanation; but in the turbine, where the steam flows in a continuous or nearly continuous current, it must be accomplished by making the passages through which the steam flows with sides diverging and cross-sectional areas gradually increasing. It is only by this means that the potential energy of the steam can be fully converted into kinetic energy, and the steam have its highest possible velocity, which velocity is to be transmitted to the buckets of the wheel and cause the turbine wheel to rotate. Theoretically these passages should increase in area directly as the specific volume of steam at the successive points and inversely as its velocity.

Steam issuing from a nozzle under these conditions will have a velocity of from 3,000 to 4,000 feet a second and if it impinges against the blades of a wheel the latter should have a peripheral velocity of about half this to utilize completely the total energy of the steam. In the De Laval turbine, which operates on this principle, the peripheral velocity is frequently as high as 1,200 feet a second, or as high as safety will permit with the strongest materials for its rotating member.

It is desirable, and in fact necessary, to secure a slower speed of rotation than this for best results, provided there is no sacrifice of economy in consequence, and this is brought about in several other types of turbines through compounding. A compound turbine may be built either for water or steam, and it is entirely possible for a water jet to flow at such great velocity as to make compounding desirable for a water turbine. The principle of compounding is very simple and is thus explained in Bodmer's textbook "Hydraulic Motors:"

"If a turbine is allowed to run at a much lower speed than at the best, the water leaves the buckets with a very considerable absolute velocity, and there is consequent loss from unutilized energy. This energy might, however, be usefully employed in driving a second turbine, the water, after leaving the first, being deflected by a set of stationary guide vanes to cause it to enter the second wheel at the proper angle. Both turbines could be keyed to the same shaft and their speed would be much lower than that of a single turbine driven by the same head of water and utilizing it to the same extent. This arrangement would constitute a compound turbine and it is clear that, instead of two wheels only, three or more might be employed in the same way, the speed being lower the greater the number of wheels. The only object in using a compound turbine in preference to a single one would be to reduce the speed in cases where the head was great and high velocity of rotation inconvenient or impracticable."

There are different methods of taking advantage of this principle of compounding, the first one to attract attention being that of the Parsons turbine, in which the steam flows through the wheel in a direction parallel to the axis and expands continuously from boiler pressure to vacuum. There are alternate rows of guides and vanes as in Fig. 3. The steam flows through a fixed ring of directing blades onto a revolving ring of similar blades, and so on, its pressure being reduced a few pounds, say two or three, at each step. Assume, for illustration, that the steam expands from 100 pounds pressure to zero in its passage and that there are 40 rows of guides and vanes. Assuming the coefficient of expansion to be the same throughout, the pressure would drop $2\frac{1}{2}$ pounds at each step and the velocity of flow corresponding to this difference of pressures would be only about 400 feet per second, as against a velocity of some 3,000 feet per second, such as would occur if complete expansion were to take place in a nozzle at the start, before the steam came in contact with the blades. The theoretically correct peripheral velocity of the turbine wheel, therefore, would be one-half of 400, or 200 feet a second, as against 1,500 feet a second where complete initial expansion takes place.

The Curtis method of applying the compound principle is different from this and enables the wheel to be constructed with a fraction of the number of blades of the Parsons wheel, although it has the disadvantage of possible erosion of the passages, through the use of steam at much higher velocities. This action is much reduced, however, with superheated steam, and we are informed that it is not marked in the machine that has been under test at the works the past two years. In the Curtis turbine a steam nozzle is employed to expand the steam, and give it a high velocity before it comes in contact with the blades, but the expansion is not entirely complete in the nozzle, Mr. Curtis preferring to have

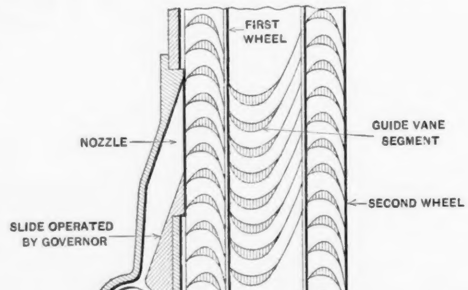


Fig. 4. Diagram of the Curtis Turbine in its Simplest Form.

a certain amount occur in passing through the wheel to overcome any retardation that may take place through friction between the blades and the steam. The nozzle is a modified form of the De Laval nozzle. The wheel is designed to run at a much lower speed than half the velocity of the impinging steam, so that when the steam issues from the first set of blades it has a high residual velocity; and this, in turn, is taken up in part by a second set of rotating blades, and so on.

For illustration, suppose the steam to start with a velocity of 3,000 feet per second; once compounding would reduce the required velocity of the wheel by two, or to 750 feet per second, instead of 1,500 feet, as with a single wheel; and

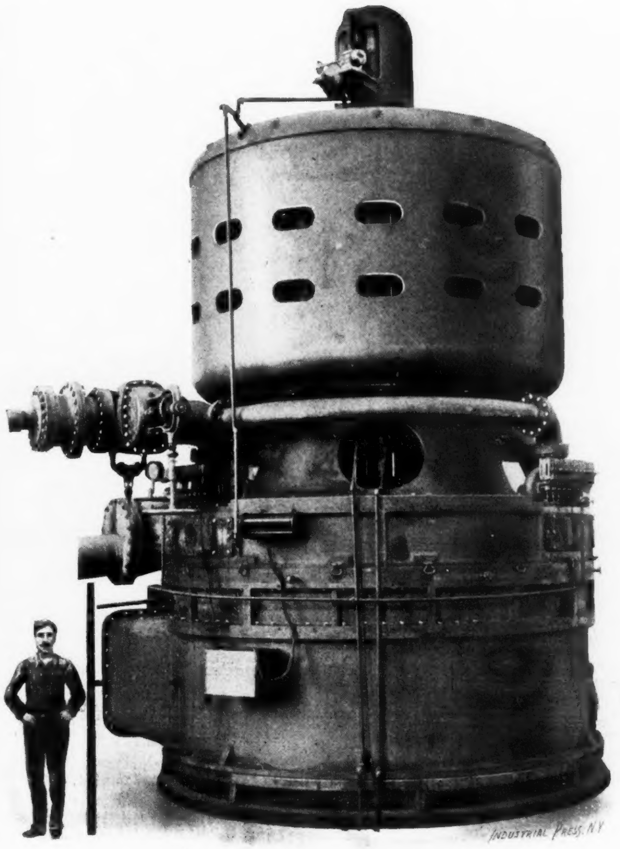


Fig. 5. 5,000 K. W. Curtis Turbine Direct-connected to Generator.

Fig. 6. 5,000 K. W. Turbine Wheel with Buckets Attached.

twice compounding would reduce the velocity to 500 feet per second. This simple illustration shows why the speed reduction under the Curtis system can be attained with so small a multiplicity of parts.

is a group of curved blades in the form of a short segment fixed to the interior of the turbine case. The nozzle is of rectangular cross section, so designed that one side of it can slide under the action of the governor without altering the

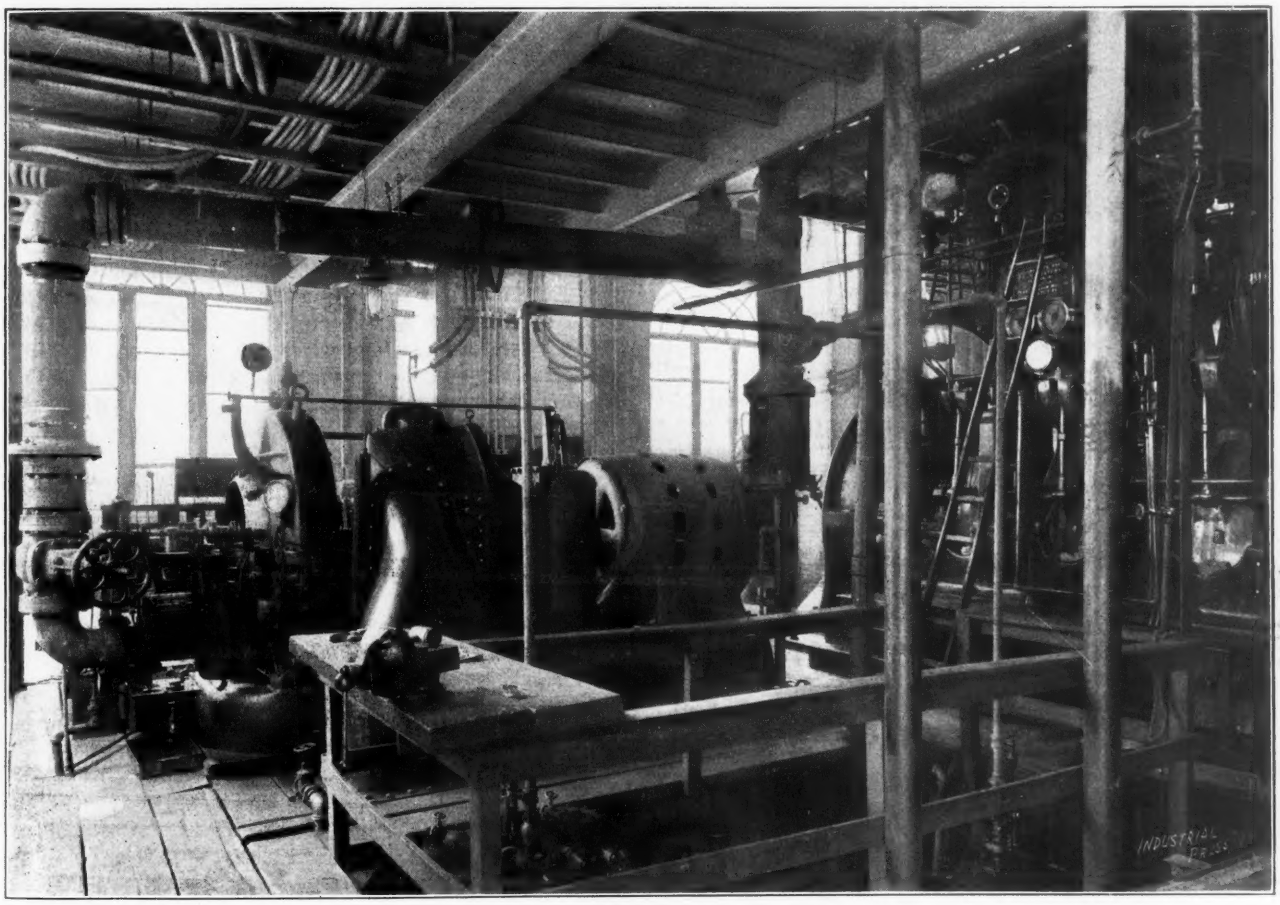


Fig. 7. 500 K. W. Horizontal Turbine, Direct-connected to Generator, operating in Power plant of General Electric Company's Works.

In its simplest form the Curtis turbine consists of two rings of curved buckets, as in Fig. 4, mounted upon disks revolving with the shaft. Between the two revolving rings

ratio between the inlet and outlet area of the nozzle, by which means the quantity of steam delivered is adjusted to suit the load.

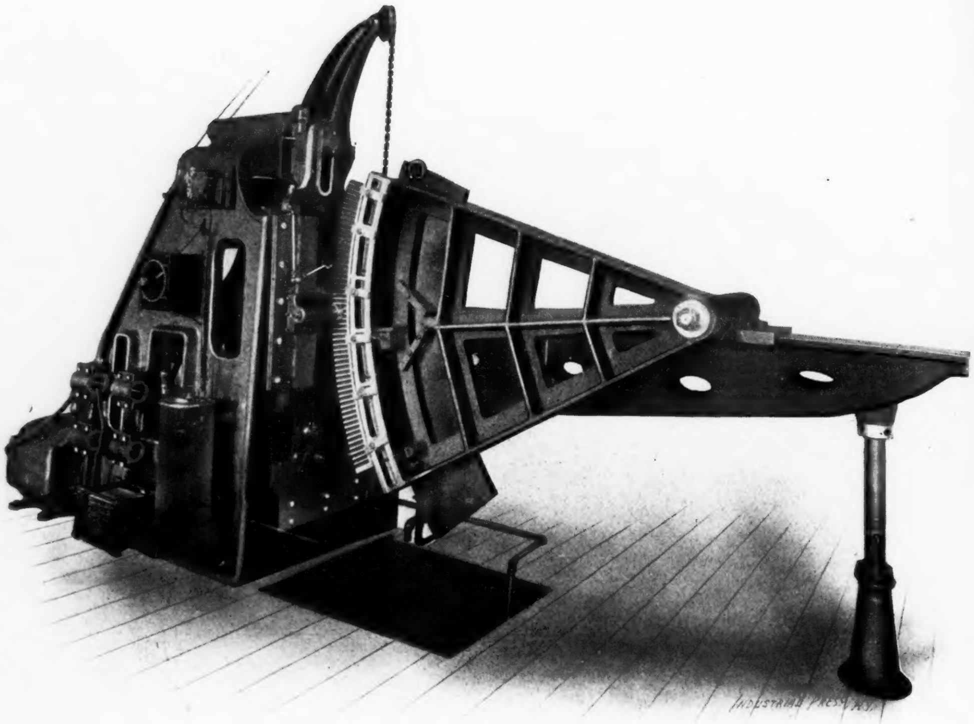


Fig. 8. Riddell Bucket Cutter at work on a Steel Segment, Cutting Buckets out of Solid Stock.

In its practical form, instead of there being a single nozzle, there are several ranged in a row, and instead of two sets of blades there is provision for several stages of expansion. The arrangement is shown in diagrammatic form in Fig. 12. Steam enters through the series of nozzles, forming a broad belt of steam, and the quantity admitted is regulated by a series of poppet valves, one for each nozzle. Regulation is effected by opening or closing these valves automatically, and for fine regulation, involving a less quantity of steam than flows through any one nozzle, throttling in one nozzle is resorted to. In the 5,000 kilowatt turbine there are three sets of these nozzles, spaced at 60-degree angles, and the steam passes through three sets of blades into an intermediate receiver, in which the pressure is approximately that of the atmosphere. From thence it passes through a second set of guide passages, or nozzles, which expand the steam nearly to the vacuum pressure and the velocity of steam is abstracted by three more sets of blades. The second row of nozzles occupies the whole circumference of the wheel, to allow for the great volume of the low-pressure steam. The turbine shaft is supported by a step bearing in which

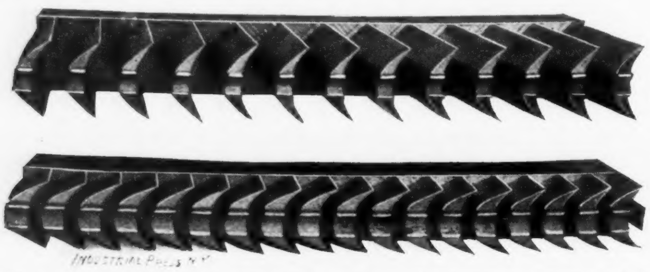


Fig. 9. Bucket Segments: The lower one for High-pressure Steam and the upper one for the Steam after it has expanded to a lower pressure.

the thrust is taken by oil under pressure. The generator shaft is axially in line with the turbine shaft, and flexibly connected with it.

Referring to the illustration of the turbine in Fig. 5, steam enters through the main steam pipe, which is shown connecting with two of the series of nozzles, and below is the casing surrounding the two turbine chambers and space for the intermediate receiver between. The governing mechanism is controlled by electrical connection with the governor, the latter being at the extreme top of the machine. In Fig. 13 is a diagram showing the principle of the device. The governor at G connects with a cylinder R on the surface of which is a series of contact points arranged spirally, so that, as the cylinder turns one way or the other, these points will come in contact successively with corresponding points from which the vertical wires extend and close the circuit through these wires in succession.

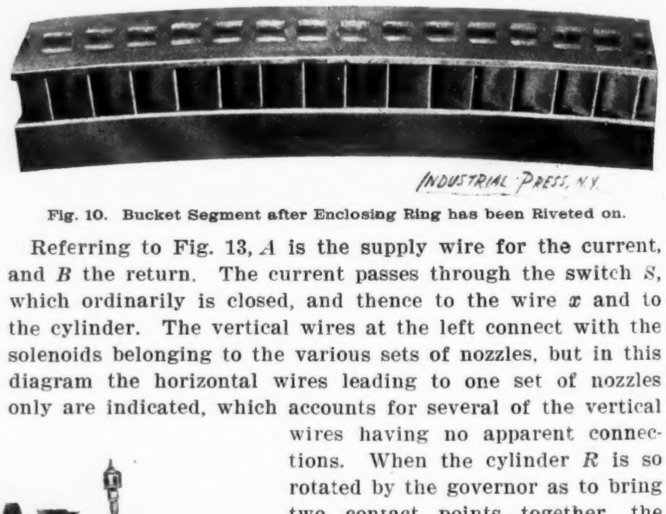


Fig. 10. Bucket Segment after Enclosing Ring has been Riveted on.

Referring to Fig. 13, A is the supply wire for the current, and B the return. The current passes through the switch S, which ordinarily is closed, and thence to the wire x and to the cylinder. The vertical wires at the left connect with the solenoids belonging to the various sets of nozzles, but in this diagram the horizontal wires leading to one set of nozzles only are indicated, which accounts for several of the vertical wires having no apparent connections. When the cylinder R is so rotated by the governor as to bring two contact points together, the current energizes the corresponding solenoid at T, and thence passes to the return wire B. Should the turbine speed up above normal, the governor arm drops and breaks the current at the switch S and all of the solenoids are thrown out of action and their valves close, shutting off steam.

The nozzle valves are not operated directly by the solenoids, but through the medium of small auxiliary valves which the solenoids control and which serve to create a balanced or unbalanced steam pressure, upon the faces of pistons attached to the nozzle valve spindles. One face of each of the pistons is

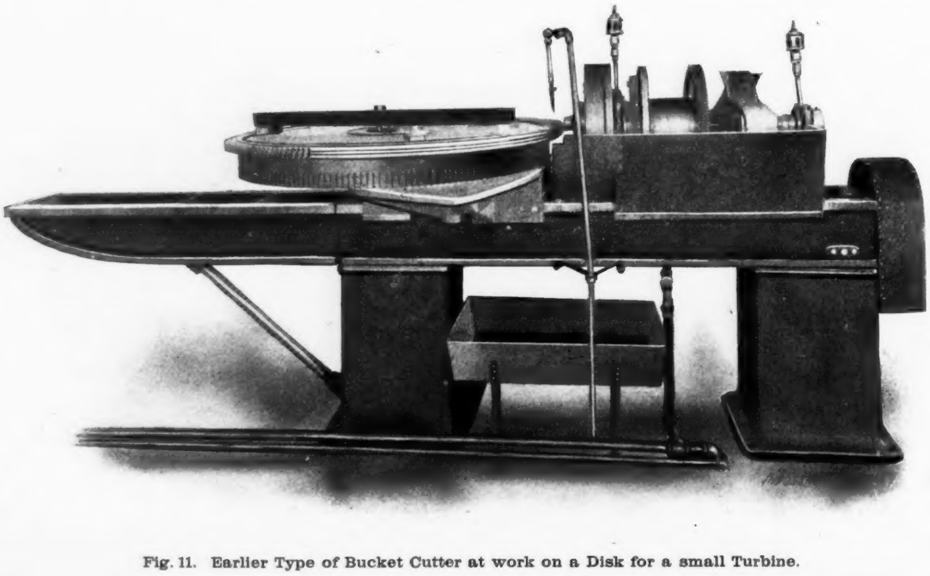


Fig. 11. Earlier Type of Bucket Cutter at work on a Disk for a small Turbine.

always exposed to the pressure within the steam chest and the auxiliary valve in one position admits steam to the opposite side of the piston. When this happens the pressure is balanced and the nozzle valve closes, the action being assisted by a small spring. When the cylinder space back of a piston or on the side away from the steam chest, is opened to the exhaust by its auxiliary valve, the piston is unbalanced and the valve will open, from the fact that the area of the piston is greater than that of the nozzle valve.

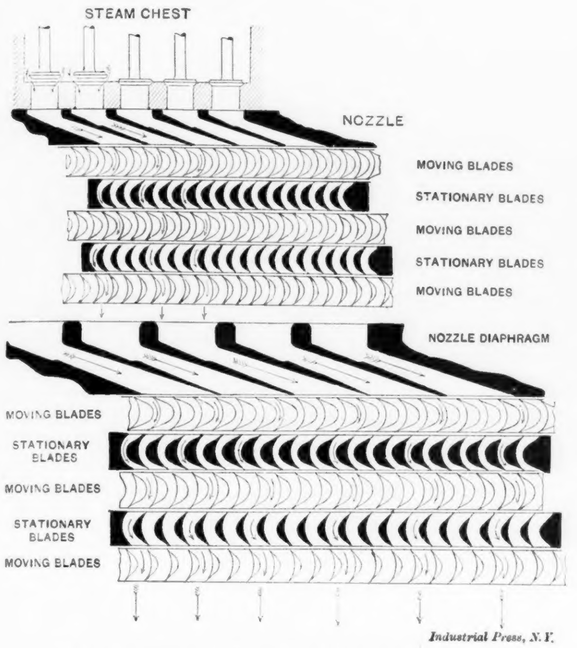


Fig. 12. Diagram of Curtis Turbine in its Latest Form.

The most vital points in a steam turbine are the buckets, since they, and the spaces between them, must be shaped exactly right to give the correct direction of flow and highest mechanical efficiency, and also to provide for the progressive expansion of the steam. The buckets of the Curtis turbine are cut out of the solid metal by special bucket cutting machines. For the smaller sizes of wheels the blades are cut from the disks comprising the wheels, and for the larger sizes the buckets are cut from segments of steel and then bolted around the periphery of the disks. In Figs. 9 and 10

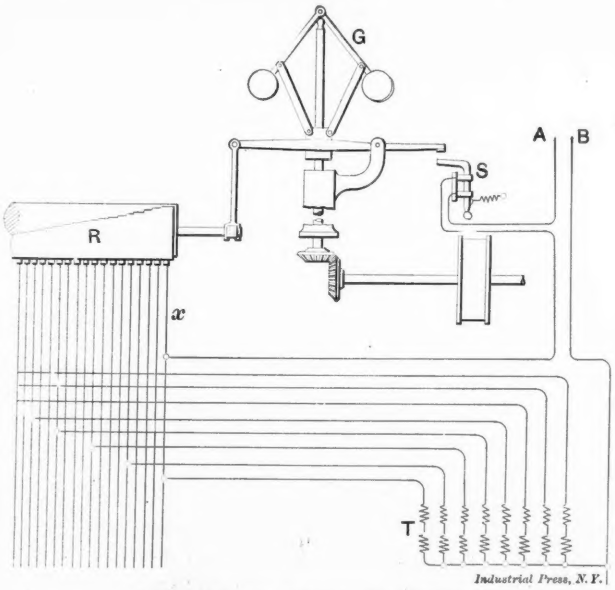


Fig. 13. Diagram of Governing Apparatus.

are shown bucket segments, in the first instance as they appear after machining and in the second with a rim of steel riveted on, closing the outer openings of the curved passages between the buckets. The view in Fig. 4, already referred to, shows the completed wheel of the 5,000 kilowatt turbine.

While this process of making the buckets produces very nicely finished work, it is at best an expensive process, calling for special and expensive machines, which have taken a long time to design and develop. There are about twenty machines now in use. In all of them a single-pointed cutting tool is employed, the tool being so guided by the mechanism that its cutting edge will be in correct position for cutting effectively at all points of the curve. In the older machines the tool was given a motion of rotation around the circumference of a circle (approximately, depending on the shape of the buckets), and as it passed the bucket segment would remove a chip. The tool was gradually fed into the work as the cutting advanced. In the latest type the tool is given

Fig. 14. Rig for Planing Bucket Segments.

an oscillating motion, back and forth across the face of the segment. On the forward stroke the tool advances for the cut and on the return withdraws for clearance. The machine of this type is partly pneumatic in its action, and is an exceedingly interesting piece of mechanism. After the patents, now pending, are issued we hope to publish more about it.

* * *

I very vividly remember, while serving my apprenticeship as a machinist in a railroad shop that the temperature in the shop often dropped below 40 degrees and frequently to freezing if the outside weather was within 15 degrees of zero. With a temperature of 40 degrees a workman's hands become numb, and it is almost impossible to do good work with hand tools. This shop was considered by those in charge as being amply heated with an overhead direct steam system. The employees, instead of working to keep warm, as a rule chose to loaf to keep warm, and I do not believe that the amount of work produced on such cold days, when estimated very conservatively, amounted to more than 75 to 80 per cent. of the normal output. In this building there were about 150 employees earning approximately $2.50 per day; considering, however, the output to be 85 per cent. the loss on cold days amounted to something like $37.50.

An efficient heating plant for this shop would cost about $3,750 complete. Without considering the cost of steam, of which there was plenty of exhaust going to waste; allowing for depreciation, etc., making liberal total of 12 per cent. or $450 per year as the amount that the cost of the heating plant should earn, it would take only twelve days with the thermometer below 15 degrees above zero to make the expenditure a paying investment.—J. I. Lyle, in a paper before the New York Railroad Club.

* * *

What is called a triple typewriter is being manufactured by a concern in Cincinnati. The machines are built principally for use in large shoe manufacturing concerns in making out their order tickets for the factory. Nearly all such factories are divided into three departments, each of which requires separate tickets, and as these tickets are made of heavy cardboard carbon paper cannot be used to make duplicates. The triple typewriters are made from three single typewriters so joined together that they operate with one keyboard. The operator finds it no more difficult to operate one machine of this kind than a single machine.

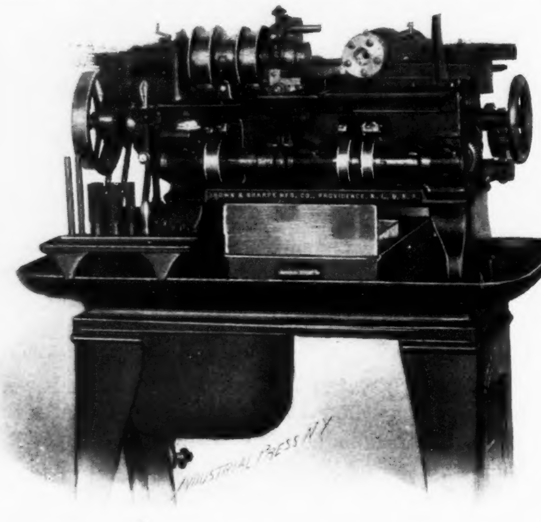
DIRECTIONS FOR CAMMING THE BROWN & SHARPE AUTOMATIC SCREW MACHINE.

RALPH E. FLANDERS,

The Brown & Sharpe automatic screw machine, as now made, has three tool carrying slides—a front cross slide, a back cross slide, and a turret slide. The back cross slide is controlled by a cam fast to shaft *A* (Fig. 1) through the medium of levers *B* and *C*, and the front slide is controlled by a similar cam through lever *D*. The turret slide is controlled by a cam on shaft *E* (Fig. 2) rotating in unison with the cross slide cams, and acting through lever *F*. The motion for feeding the stock, revolving the turret, and reversing the spindle, is taken from a driving shaft which runs at constant speed. Through change gears and a worm and worm wheel this shaft also rotates the cross slide and turret cams at a speed suitable for the piece being made. Bearing these essential points in mind, we will proceed to draw out the cams for making a model piece.

Laying Out Operations.

Fig. 3 shows a screw which was made of gun iron for a foreign rifle works. The particular dimensions on this piece are the diameter .1573, the length .630, and the thread .126 diameter x 42 threads per inch, or nearly No. 5-42. For these dimensions gages had been provided. The operations were laid out as shown; 1st, box-tool, to rough turn body size, and finish turn thread diameter; 2d, box-tool to finish turn



Brown & Sharpe No. 00 Automatic Screw Machine.

body; 3d, die and pull out die holder for threading; 4th, form tool for finish around and under head; 5th, cut-off tool to sever finished piece, and neck and bevel unfinished piece for threading; 6th, feeding stock to stop in turret and revolving turret. The thread diameter is finished by a second blade in the first box tool, thus allowing the finishing box tool blade to clear this portion of the cut and shorten the throw required. The work is fed to a stop to bring dimension .630 correct.

Spindle Speeds.

In laying out a set of cams, the first point to determine is the rate of spindle speed. Gun screw iron can be readily turned and formed with a surface speed of 60 feet per minute. It has been formed at 90 feet per minute with fine feed, while with coarse feed it sometimes has to drop to 45 or 50 feet. Sixty feet per minute is, however, a conservative rate of speed for this job.

For threading on this fine pitch and soft material the rate may run anywhere from 25 to 40 feet per minute. It is well to remember that we can scarcely get the threading speed too low in an automatic screw machine, so the slower it can be done without sacrificing the production on the other operations, the better.

Now, consulting the spindle speed chart furnished with the No. 00 size machine, into which we will put this job, we find that 1,080 revolutions per minute appears to be the most suitable speed. This will give about 67 feet per minute for turning and forming, and about 35 for threading. To obtain the surface speed, multiply the diameter of the work in inches or fractions thereof by 3.1416 to find the circumference; multiply this by the revolutions per minute, and divide by 12 to get the answer in feet. Better yet, look up diameter and revolutions in one of the numerous tables to be found in catalogues and reference books.

Feeds.

For feeds, with this surface speed, .006 would be about right for rough turning, with .008 for the finishing cut. For forming this width, we could not safely take much more than

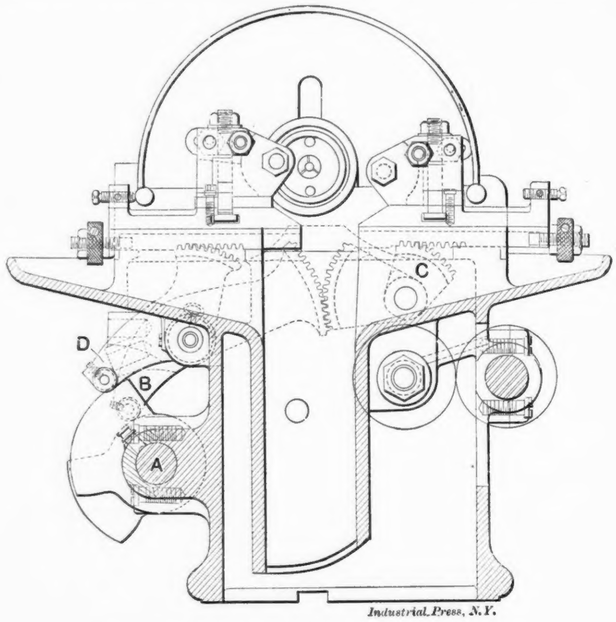


Fig. 1. Section showing Operation of Cross-slides.

.0004, with .0013 for cutting off. These feeds are given in Fig. 3, and refer in all cases to the thickness of the chip, or the distance the tool advances for each revolution.

Number of Revolutions to Make One Piece.

We next want to know about how many revolutions of the spindle it will take to make one piece. For rough turning we have a length of .630 to turn at .006 per revolution; this will give about 105 revolutions for this operation. (Note that

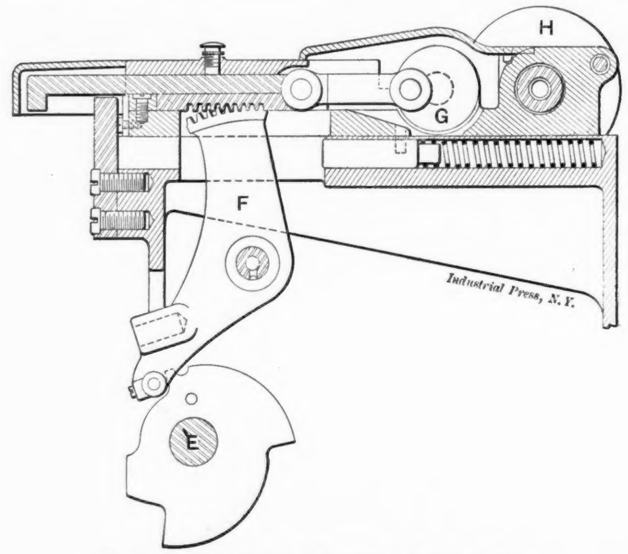


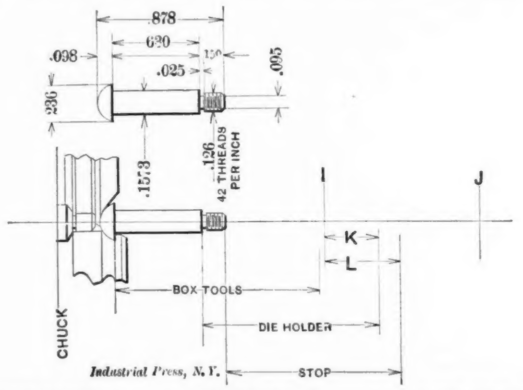
Fig. 2. Section showing Operation of Turret-slide.

the threaded diameter was rough turned by form tool, so that the first blade passes freely over this part without cutting.) It takes $\frac{1}{2}$ second to revolve the turret on this machine. If the spindle goes 1,080 revolutions per minute; in $\frac{1}{2}$ second it will go $1{,}080 \div 60 \times \frac{1}{2} = 9$ revolutions. Better add on a few revolutions here and make it 13 for good luck. Finish turning .630 in length with a feed of .008 will take $.630 \div .008 = 79$ revolutions. Revolving turret, as before, 13 revolutions.

To find the number of revolutions required for threading, we find the number of threads on the piece by multiplying the pitch, which is 42, by the threaded length .15; this gives

us about 6. Add, say, 2 revolutions for clearance and multiplying by 2, gives 8 revolutions on and 8 revolutions off, or 16 revolutions for threading.

The next time the turret is revolved, the form tool is in action, so we need not reckon in the revolutions. We form from stock .236 in diameter down to .157, which gives a difference of .079 in diameter, or about .040 difference in radius. Add .003 for clearance, and call the throw of the form tool .043. With, say, .00043 feed, this will give 100 revolutions for this operation. To save time, we will overlap the movements of the front and back slides, timing the cams in such fashion that when the form tool has completed its cut, the parting tool will have cut into the neck between the screw-



FRONT SLIDE.	TURRET SLIDE.	BACK SLIDE.
	Rough Turn—Box Tool .006.	
	Revolve Turret	
	Finish Turn—Box Tool .008.	
	Dwell.	
	Revolve Turret.	
	Thread—Die Holder and Die.	
Form—Circular Tool .0004.	Revolve Turret twice.	Cut-off Circular Tool .0013
	Feed Stock to Stop.	
	Revolve Turret.	

Fig. 3. Screw made on Turret Lathe and Operation of Slides.

head and the chuck, as far as can be done safely and still support the work for the form tool to finish. In the present instance the back cut-off tool cuts down to a diameter of about .110 before the form tool was withdrawn. This gives us a throw of about .055. Now it will be noticed in Fig. 3 that the face of the cutting off tool is made on an angle. This is done, as shown in Fig. 4, to get rid of the teat which is always left on work parted by a dull, straight faced tool. This angular cutting edge causes the piece, in breaking off, to leave the major portion of the teat on the unfinished stock still in the machine, where the further advance of the tool shaves it off. Fifteen degrees has proved to be a suitable angle for steel and iron, while a somewhat greater angle, say from 20 to 25 degrees works better with brass or bronze. It is evident that we must add to the throw already found an amount equal to *S* in Fig. 4, which equals the width of the blade multiplied by the tangent of the angle. These values have been worked out in the table shown, for different widths of tool, and angles suitable for steel and brass respectively. With a blade .035 wide and an angle of 15 degrees, the by-travel amounts to .010. Besides this last allowance we should add on about .005 to provide clearance at each end of the movement of the tool. This gives us in all .055 + .010 + .005 = .070 for the throw of the cutting off tool to be used in estimating the number of revolutions of the spindle to make the piece. At .0013 feed this will give us .070 ÷ .0013 = 54 revolutions. Revolving turret as before, 13 revolutions. Feeding stock, same as revolving turret, about 13 revolutions. The total number of revolutions needed to make one piece, will be as follows:

Rough turn	105	revolutions.
Revolve Turret	13	revolutions.
Finish turn	79	revolutions.
Revolve turret	13	revolutions.
Thread	16	revolutions.
Form	100	revolutions.
Cut-off	54	revolutions.
Feed stock	13	revolutions.
Revolve turret	13	revolutions.
Total	406	revolutions.

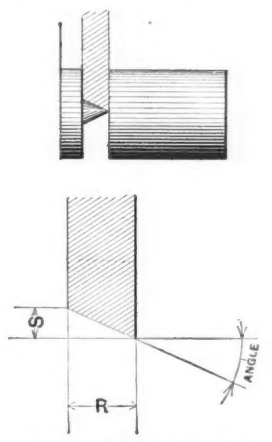
Our spindle speed is 1,080 revolutions per minute, or 1,080 ÷ 60 = 18 revolutions per second. Then it will take 406 ÷ 18 = 23 seconds, about, to make this piece. This will give a net production, after deducting 10 per cent. for sharpening tools, etc., of about 1,400 per day.

Laying Out the Cams.

Proceeding now to lay out the cams we will first lay out the lead cam by which the turret is operated. After we have drawn a circle to represent the diameter of the blank from which the cam is made, we will lay out on the circumference a distance sufficient for the first operation. It is best, in doing this work, to consider the circle as divided into hundredths instead of degrees and minutes and to facilitate this, it will be found convenient to use a piece of bristol board, cut out to fit the diameter of the cam blank, spaced off with the dividers, and graduated as shown in Fig. 5. This will save spacing off each circle separately.

The first operation, rough turning, took about 105 revolutions. If the spindle revolves 18 times per second; in the 23 seconds it takes to make one piece it will revolve 414 times, agreeing closely with our approximate estimate. If the spindle revolves 414 times in making one piece, or in other words, to one revolution of the cam shaft, each 1-100 of the cam periphery represents 414 ÷ 100 = 4.14 revolutions of the spindle. Then, if it takes 105 revolutions for the first operation, this portion of the cam will extend over 105 ÷ 4.14 = 26 spaces. Having found this division with our improvised protractor, draw a line through it and mark it 26, as shown on the lead cam in Fig. 6.

The next point to determine is the height of the cam lobe for this operation. Referring now to Fig. 3; lay off on the center line the nearest and furthest positions of the face of the turret in relation to the face of the spindle chuck, and draw vertical lines *I* and *J* through these two points. Now find on the box tool it is proposed to use, the working length, or the distance from the cutting edge of the first blade to the face of the turret when the tool is shoved in to the shoulder. After adding 1/8 to the dimension to allow for clearance and adjustment; lay off this distance from the point where the first box tool blade ceases action, toward the lines drawn to represent the position of the turret. As shown in Fig. 3, the dimension line marked "Box Tools" falls short of the advanced position of the turret, so we will bring this lobe up to its full height. Now lay off on the zero, or starting line, a distance *M-N* equal to the required throw for this tool = .630, and connect it by a spiral with the circumference at radial 26. This will be the first lobe of the cam.



R	15°	23°
.025	.007	.011
.030	.008	.013
.035	.010	.015
.040	.011	.017
.050	.013	.021
.060	.016	.026
.080	.021	.034
.100	.027	.043

Industrial Press, N. Y.

Fig. 4. Cutting-off Tool and Allowances for Angle of Face.

An approximate method of drawing this spiral is indicated. Owing to the length and steepness of this cam, we will have to draw it in two sections, so bisect the circumferential space of 26-100, at division No. 13; and there draw a radial line. Bisect the throw laid out (*M-N*) at *O*, and strike from this point an arc cutting radial No. 13 at *Z*. Again bisect *M-O* and *O-N* at *P* and *Q* respectively. With a radius equal to the distance between *P* and the center of the cam, connect points *M* and *Z*, and with a radius equal to the distance from *Q* to the center of the cam, connect point *Z* with the top of the lobe in the circumference at radial No. 26. This will be found a very close approximation to the theoretical spiral. Only one arc

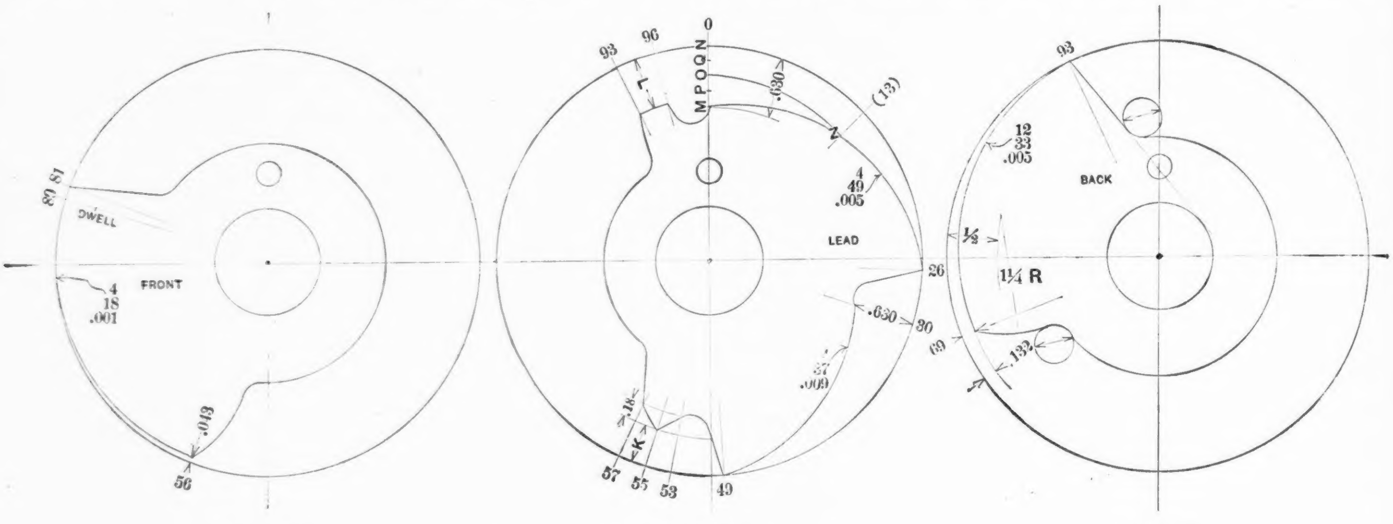
is usually needed to connect the starting and stopping points of the lobe, but sometimes it is necessary to draw a long spiral in as many as three or four sections.

It will be remembered that it takes ½ second to revolve the turret on this size machine. This makes 9 revolutions or 2-100 of the cam periphery. It will, however, ordinarily be found impracticable, when the diameter of the roll, and the angle of drop on the cam is taken into account, to get the roll down into position for a new cut in less than three spaces, and it is always well to add another space to give plenty of leeway, should it be found possible to speed the cams above the calculated rate of production. Our next radial will then be drawn four spaces beyond the last one, and will be numbered 30. Mark down on this line a distance equal to .630—the throw of the second box tool—as a starting point for the second cam lobe. We now wish to connect the top of the first lobe to the bottom of the second with a suitable drop. On the No. 00 machine, in anything from an 8-second to a 30-second cam, if the drop is drawn tangent to the 1¼-inch center hole it is about right. Cams faster than this will require an easier drop, while on slower cams it may be made a little steeper. Draw then a line tangent to the center hole from division No. 26 on the periphery and connect it with the starting point of the second lobe by an arc with a radius equal to that of the cam roll. The second lobe is drawn the same as the previous one—first find the number of spaces needed, here 19, draw a radial at division No. 49, and connect the two points with a spiral, substantially as before.

will give us the top of the threading lobe. Measure down .180, our calculated throw, from this point on radials Nos. 53 and 57, and connect the points thus found with an arc—a single one will do here—substantially as before described.

It will be noted that it is unnecessary in this machine to make provision on the cam for carrying the turret slide to its extreme backward limit before revolving the turret. We merely let the cam roll drop down a little below the starting point of the next lobe; the crank disk and connected mechanism, indicated at *G* in Fig. 2, disconnects the slide from cam lever *F*, draws it to the extreme rear, revolves the turret, and again brings it up and connects it with the lever, ready for the next operation. This makes the time necessary for revolving the turret much shorter than if we had to let the roll clear down to the bottom of the cam each time. While the cross slide tools are in action, there is nothing for the turret to do, so drop the cam down 1⅛ below the circumference, the limit of the backward movement of the turret in this machine.

The next operation is forming, done by a circular tool in the front slide. As the thread on our sample is so far back on the piece, the dieholder and form tool are clear of each other, and the front cam may commence work immediately after the spindle reverses. In the circle which we have drawn for our front cam blank draw radial 56, 1 space beyond where the spindle reversed at 55 on the lead cam. One hundred revolutions were appropriated for this cut. This will give 24 divisions for the spiral, which should have a rise of .043 to agree with the calculated throw for this operation.



Front Cam. Lead Cam. Back Cam.

Fig. 6. Cams for making the Piece shown in Fig. 3.

The pitch of the threaded portion of the sample is 42 per inch. As this part is .150 long, there will be 150 × 42 or 6.3 threads on one piece; adding 2 threads for good measure, we have 8.3 revolutions, or 2 spaces as the portion of cam periphery needed for threading on. Furthermore, if there are 8.28 revolutions actual, in the 2 spaces, and the pitch is 42, the throw of the die will be $\frac{8.28}{42} = .197$. Die holders for use in automatic screw machines should be made to pull out against a light spring, in order that the turret motion may merely start the die on. The pitch of the thread will feed it into the work, while the turret lags after at a slightly lower rate. To allow for this, we will subtract about 10 per cent. from the amount given, leaving .180 for the throw of this part of the cam. Allow 4 spaces for revolving the turret as before; 2 spaces, as calculated above, for threading on; and 2 more for threading off; drawing radials at 53, 55, and 57.

Now find the height of this lobe of the cam. In Fig. 3, set the dividers to a distance equal to the amount the face of the die in the holder we intend to use projects beyond the face of the turret, plus ⅜ for clearance. Lay off this distance from point where the thread ceased; and dimension *K*, the length by which it projects beyond the line of the turret *I*, will be the amount we must cut down from the circumference of the cam. Lay off this distance on radial No. 55, and it

In order to allow the tool to clean out the chip and give a good finish, in all cases where a tool is fed onto a finished surface, whether it is a box tool, a hollow mill, or a cross slide tool, it is advisable to add a dwell of a few revolutions at the end of the spiral on the cam. Accordingly, we allow another space from 80 to 81, which is made concentric with the cam shaft center, so that the tool may rest on the finished diameter for 4 or 5 revolutions. The cross slide cams are, of course, brought up to the full diameter as a rule.

Our allowance for cutting off was 54 revolutions, but it will be remembered that this accounted only for that portion of the cutting off which was done after the forming was completed. As there is plenty of time for it, as a measure of precaution, and for convenience in setting up as well, the throw of this cam should be great enough to sever the piece from the stock diameter, instead of waiting to commence work on the reduced neck left by the form tool. Of course the blade will be cutting air the first part of its travel, but experience shows that this will not dull the cutting edge. The diameter of the stock is .236; allowance for bevel on cut-off blade .035 wide is .010; clearance is .004; this will give $\frac{.236}{2} + .010 + .004 = .132$ for cut-off throw. With a feed of .0013 this means 100 revolutions or 24 spaces. By referring to our list of operations it will be noted that after the cutting off is completed we have to provide for feeding stock and

revolving turret. The turret is revolved in 4 spaces as before; although the feeding of the stock takes the same amount of time, in practice it is seldom found necessary to add an extra space to that absolutely needed, so the allowance for this will be 3 spaces. This makes 7 spaces in all, so our cutting off cam will end at $100 - 7 = 93$, and begin at $93 - 24 = 69$. Lay out the cam between radials 69 and 93, with a throw of .132, and draw a suitable rise and drop. These quick motion curves should be drawn about as dimensioned for cams on the No. 00 machine. The builders send with the outfit directions for laying out those curves for the different sizes of machines, but if these are not at hand, a little judicious experiment will suggest what is about right for the case in hand.

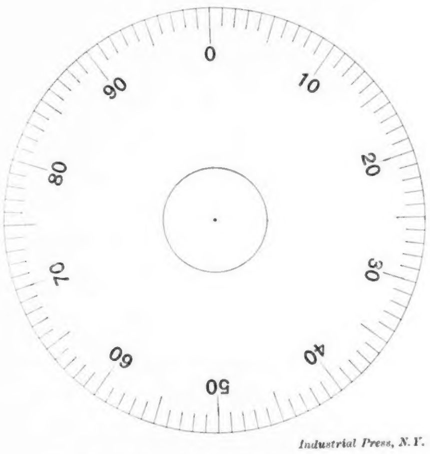


Fig. 5. Protractor for Laying Out Cams.

Returning again to complete the lead cam, we lay out a lobe for the stock stop in the space between radials 93 and 96, which was reserved for feeding stock. This lobe is made a "dwell," and its height is determined from the stop we propose to use, in the same way as was described for the other tools in connection with Fig. 3. After making a little drop for the cam roll between 96 and 0, while revolving the turret, and having run up to connect again with the starting point, the cam is completed. To finish the sample up in good style, a pointing tool should have been used in the turret to clean up the thread end of the screw while the forming was in progress. As the party for whom the work was done did not care to bother with this, it was omitted, but the method for laying out a lobe for such an operation would not differ from that for the rest of the cam.

The first time the cams are outlined, make the pencil lines soft, as it is often necessary to make slight changes in the cams after they have been laid out and compared with each other. The calculations should also be gone over a second time, to see that no mistake has been made. Let us prove our calculations in regard to the depth the cutting off tool has penetrated at the completion of the forming. The total throw is .132, and the total number of spaces occupied is 24; of these 12 are simultaneous with the forming, so that the depth of cut reached at radial No. 81 is $\frac{12}{24} \times .132 = .066$. Subtracting the clearance, we have about .064. The radius of the stock is $\frac{236}{2} = .118$. The diameter of the supporting teat is then $2(.118 - .064) = .108$. As the form tool cut extends only about 5-32 beyond this teat, the conditions are well within the limits of good practice, that the length of surface formed shall not exceed 2½ times the supporting diameter.

If the thread cam had been a little longer and steeper, it would have been found advantageous to lay it out in a more elaborate manner. Fig. 7 shows the method. It is required to draw a threading lobe to give a movement of .625 in 4 spaces on, and 4 spaces off, the lobe to be cut down ¼ inch from the circumference. Supposing the apex of the cam to be on radial No. 75; with center on this line draw a circle equal in diameter to the cam roll, with its bottom the required distance (¼ inch) from the periphery. Through the center of this cam roll draw an arc concentric with the cam and cutting radials 71 and 79. On radial 79 lay off from this arc, toward the center of the cam a distance, .625, equal to the required throw. Now divide this distance, and the arc on either side of radial 75, into any convenient number of parts, 4 in this case. With compass point at the center of the cam and a radius T equal to the distance between the center of the lead cam and the fulcrum of the lead lever, strike an arc. With centers in this arc, and a radius U equal to the distance from the fulcrum of the lead lever to the center of the roll, strike arcs through the center of the cam roll circle, and also each of the division points in its arc. Draw arcs also concentric with the cam through the division points on radial 79. Where each of these arcs intersects its mating arc drawn from the fulcrum of the lever, draw circles the diameter of the cam roll, as shown in the figure. If we now draw curves on each side of radial 75 tangent to the under side of these cam roll curves, we have our lobe. It will be noted that this lobe is narrower than the space between 71 and 79, that it is less than .625 high, and its apex is more than ¼ inch from the periphery, but if carefully laid out and made, it will give the required results with a pull out die holder.

General Remarks.

A few points to be careful about are copied here from a note book in which the writer has recorded some of his mistakes. Give plenty of clearance between operations when there is any likelihood of interference between cross slide and turret tools. Be sure that all possible burrs are removed. Always either feed to stop or face end to length where accurate work is required. Always be sure, especially in pieces made in 6 or 8 seconds with few turret tools, that time is given to revolve the turret clear around past the unused holes while the cross slide tools are in action. The different tools and operations should be arranged in such fashion as to completely remove the burrs thrown up by the different cuts. This can be done in nearly every case. We are not limited to the production for which the cams have been calculated. For instance, in the case we have been considering, we might find the stock so soft that a spindle speed of 1,320 revolutions per minute could be used. It took 414 revolutions to make one piece, so with the new spindle speed, 418 revolutions, taking 19 seconds to revolve the cam shaft, will give practically the same feeds throughout. Again, if the feeds are a little easy or a little too stiff, we may simply change the number of seconds the cam shaft is timed for, by altering the gears, as we have made provision for a little extra space for revolving the turret. When the production is changed in this way, it is sometimes necessary to change the thread lobe a trifle, but none of the other lobes need be touched.

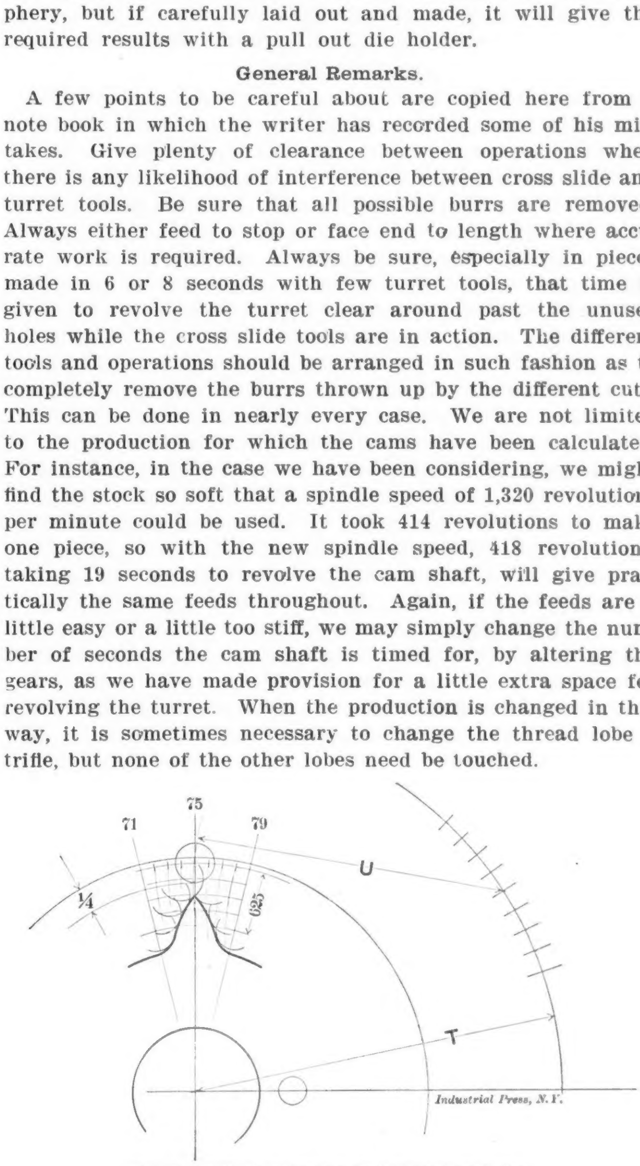


Fig. 7. Method of Laying Out Threading Lobe.

The cams are preferably made of mild sheet steel, of suitable thickness, finished on the periphery and casehardened. Plain forming and cut-off cams, and sometimes lead cams for the larger machines, when of strong design, are made of cast iron finished all over. The blanks should be turned to size and have the center hole bored and the driving hole drilled from a template. Make a copy of the cam drawings, with a hard, round ended pencil and a sheet of carbon paper, on a piece of tough manila. Include the center hole and the dowel hole in this copy, as it is by means of the small hole that the cams are timed together. Cut out the template thus drawn, locate it in position on the cam blanks, and carefully scribe the contour onto the metal. With drill and cold

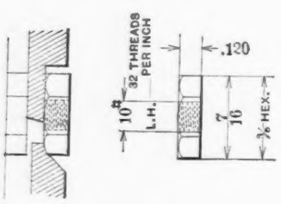
chisel remove the surplus stock and finish up the rises, drops, and idle periods with the emery wheel and file, leaving 1-16 inch or so for finish on the working surfaces. For the steep pitches, such as the thread lobes and possibly the two box tool lobes, the curve may be worked out with the file until it matches the drawing, but to get an even rise on such a slight pitch as that of our cross slide cams, it will be necessary to mill the spiral. To do this, place the cam on an arbor held in the index centers of a milling machine, drop a cutter onto the highest point of the cam, and alternately raise the knee and rotate the index head by suitable amounts until the entire surface is finished. "Millings," as they are termed, are given for the different lobes of the three cams, and they are read as follows: $\overset{4}{\underset{.001}{18}}$ on the front cam means that the index finger is to be moved 4 holes in the 18 circle, and the knee raised .001 for each cut; $\overset{12}{\underset{.005}{33}}$ on the back cam shows that we must index 12 holes in the 33 circle, and raise the knee .005; and so on.

To find the milling for the first box tool lobe on the lead cam, for instance, first find the lead, or the throw it would have if continued for a complete revolution; this will be equal to its present throw, divided by the per cent. of the circumference it occupies. $\frac{.630}{.26} = 2.423 =$ the lead of this lobe. Now divide this amount by any convenient quantity we may settle

Examples of Layouts.

A few samples are here illustrated, showing the operations, feeds, speeds, and production. It is to be understood that, on rougher work, both the feeds and speeds might be greatly increased. Another factor which might tend to greater production is the use of some of the high speed steels for roughing tools. Turning our attention to the samples illustrated, it may be interesting to notice the important points in each one. The first column relates to the front cross slide, the second to the turret, and the third to the back cross slide, and the feeds are given for each operation. When two or more items are included in parentheses, it indicates that they are all done by the same tool.

The small brass nut, sample 1, is made from hexagon stock. Brass may be turned at the highest available speed of the machine, but it is seldom expedient to thread at over 1,500 to 1,800 revolutions per minute. In deep drilling in brass, one is more liable to get the feed too fine than too coarse. A fine, broken chip will quickly clog up the flutes of a twist drill, while a heavy stiff chip will push straight out. It will be found advantageous to use straight fluted drills on this metal. The centering and facing is done with one tool, and the feed is reduced when the facing blade commences its work. The cutting off tool is given a regular feed until the point has severed the completed piece, and then the feed is doubled while the tool cuts through the air in the hole. It is always advisable to cut to the center to avoid the trouble that would follow if the drill broke and the work was not severed from the stock.



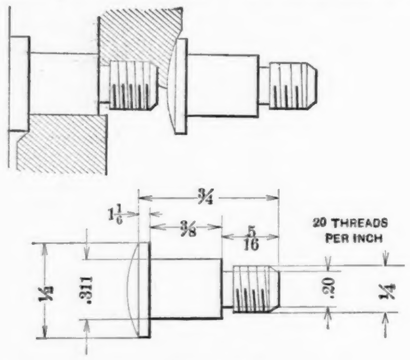
Sample 1.

Material—Brass.
Spindle, 1,440 R. P. M. Seconds each, 10.
Net production, 3,200 per day (10 hours).

(Center .0042 / Face .0021 / Dwell.)
Revolve Turret.
Drill .0058.
Revolve Turret.
Tap.

(Form .0012 / Dwell.) (1st cut-off .002 / 2d cut-off .0042)

Feed Stock.

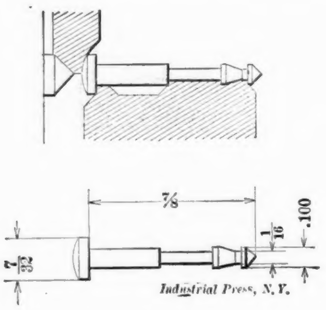


Sample 2.

Material—Steel
Spindle {Forward 300 R. P. M. / Backward 600 R. P. M.} Seconds each 70
Net production 450 per day (10 hours).

(Form .00029 / Dwell.) (1st cut-off .0014 / 2d cut-off .00064 / Dwell.)

Thread.
Revolve Turret.
Feed to Stop.



Sample 3.

Material—Steel.
Spindle, 1,320 R. P. M. Seconds each, 30.
Net production, 1,000 per day (10 hours.)

Rough Turn—Hollow Mill .0073
Revolve Turret.
(Finish Turn—Box Tool .009 / Point. .001 / Dwell.)
Revolve Turret.

(1st Form .0011 / 2d Form .00016 / Dwell.) Support.

Cut-off .0013

Feed Stock

upon as the distance we will raise the knee for each cut. This quantity may be larger for a steep pitch, and smaller for a slight pitch. Suppose we settle upon .005; $\frac{2.423}{.005} = 485.$ Four hundred and ninety is the nearest number of divisions we can get on or index head by plain indexing, and the table calls for 4 holes in the 49 circle. The amount the knee is raised being .005, the "milling" will be $\overset{4}{\underset{.005}{49}}$ read as explained above. To prove the millings, proceed as follows: $40 =$ number of teeth in index wheel; $.26 =$ per cent. of periphery occupied by lobe; $\overset{4}{\underset{.005}{49}} =$ the milling. $\frac{49}{4} \times .005 \times 40 \times .26 = .637$. This exceeds the calculated throw, but is near enough. If the two steep box tool lobes are milled, it would be advisable to use a convex cutter with a radius of cut about equal to the radius of the cam roll; this will lessen the stepped appearance the corner of a straight cutter would give to the rise. After the lobes are milled, the surfaces should be filed smooth and polished, and the cams tried in the machine before hardening. The lead cam should be stamped with the name of the piece it is to make, the spindle speed, the change gears used, and the name of the cam.

Sample 2 is an example of the method of making commonly known as "cut-off and form." Wherever the turned portion is less than about 2½ times the supporting diameter, this method will usually give the greatest production. Much longer formed cuts can of course be taken if the work is supported by a back rest in the turret. In this piece, as well as in the others shown, note the means taken to remove all the burrs possible, and so leave the work nicely finished. The form tool cuts off the burr thrown up by the cutting-off tool in necking for the thread, and by means of the 45 degree angle, cleans up the under corner of the head. The cross slide tools are set to cut with the spindle running backwards at double speed, thus greatly increasing the production, while the threading speed is kept within limits.

Sample 3, a part of one of the standard typewriters, is an extreme example of long forming. It will be noted that two feeds are used for forming. The tool takes a chip of .0011 when finishing under the head, but is slowed down to .00016 when the wide cut starts in. The work is supported by a turret back-rest bearing on the two thin strips of body diameter at the end of the piece. These examples show some of the simpler forms of work done on these machines. This system of cams lends itself very readily to complicated combinations, and the cams, tools, and attachments for some of these operations are very elaborate.

MACHINE SHOP EQUIPMENT.*—1.

PLANNING THE DIFFERENT DEPARTMENTS.

OSCAR E. PERRIGO.

We will assume that our machine shop has been erected according to the methods suggested in the former articles on the subject, which discussed the plans and mode of construction of foundations, walls, roofs, and floors, and properly provided for the prime necessities of light, heat and power. Our next duty will be to describe and illustrate its equipment with the proper machinery, tools and appliances for accomplishing the contemplated work to be done. Machines should be so arranged in groups or departments as to best subserve the purpose intended, and to manufacture the product with the least cost for handling the materials in the various stages of their progress toward the completed product, and with the most efficient arrangement for supervising the work, and still to insure the desired standard of accuracy, finish and thoroughness of the completed output.

In considering the question of the proper equipment of a machine shop a great deal depends upon the character of the product which is to be turned out. It may be that of heavy machinery requiring little or no machining except of surfaces in contact, as is the case with such work as sugar mill machinery, rolling mill work and similar product which will necessitate heavy castings and consequently a large proportion of machines for heavy planing, boring, drilling, tapping and so on, as well as large erecting space and much use of the traveling crane and other forms of lifting devices. Again, it may be of a generally lighter kind of work, as for instance, steam engines of various sizes and similar work where much more finish as well as very accurate fitting is required. Or, it may be of machine tools, the larger of which will be similar to the engine work in many respects, while the smaller machines will require a large variety of machines both for general and special work and such as are capable of producing a large quantity of very accurate work even on rather large parts.

The design of these articles is not to arrange and specify such an equipment as may be required for any certain kind or class of manufacture, or for any special line of sizes of machines, for that is manifestly impractical, but rather to suggest the proper selection and arrangement of the machines for a medium kind of work, on a practical plan which may be useful to those having charge of this class of mechanical engineering and be helpful in pointing out such machines as will be most economical in the production of certain classes of work in the more modern and up-to-date methods, and so grouping and arranging them as to make their management easy, practical and profitable.

In this connection it will not only be proper to offer some suggestions as to the class or type of machines best adapted for certain kinds of work, but also as to the methods of testing such machines to ascertain their fitness for the work to be done on them. These requirements become all the more imperative since the demand is more and more pronounced for machines of higher speed, greater strength and consequently capable of a largely increased output, as well as for machines whose parts may be rapidly changed to adapt them to a large variety of work. To this is added the demand for greater accuracy, better fitting, a superior quality of stock in their make-up, more carefully considered design and a generally finer finish.

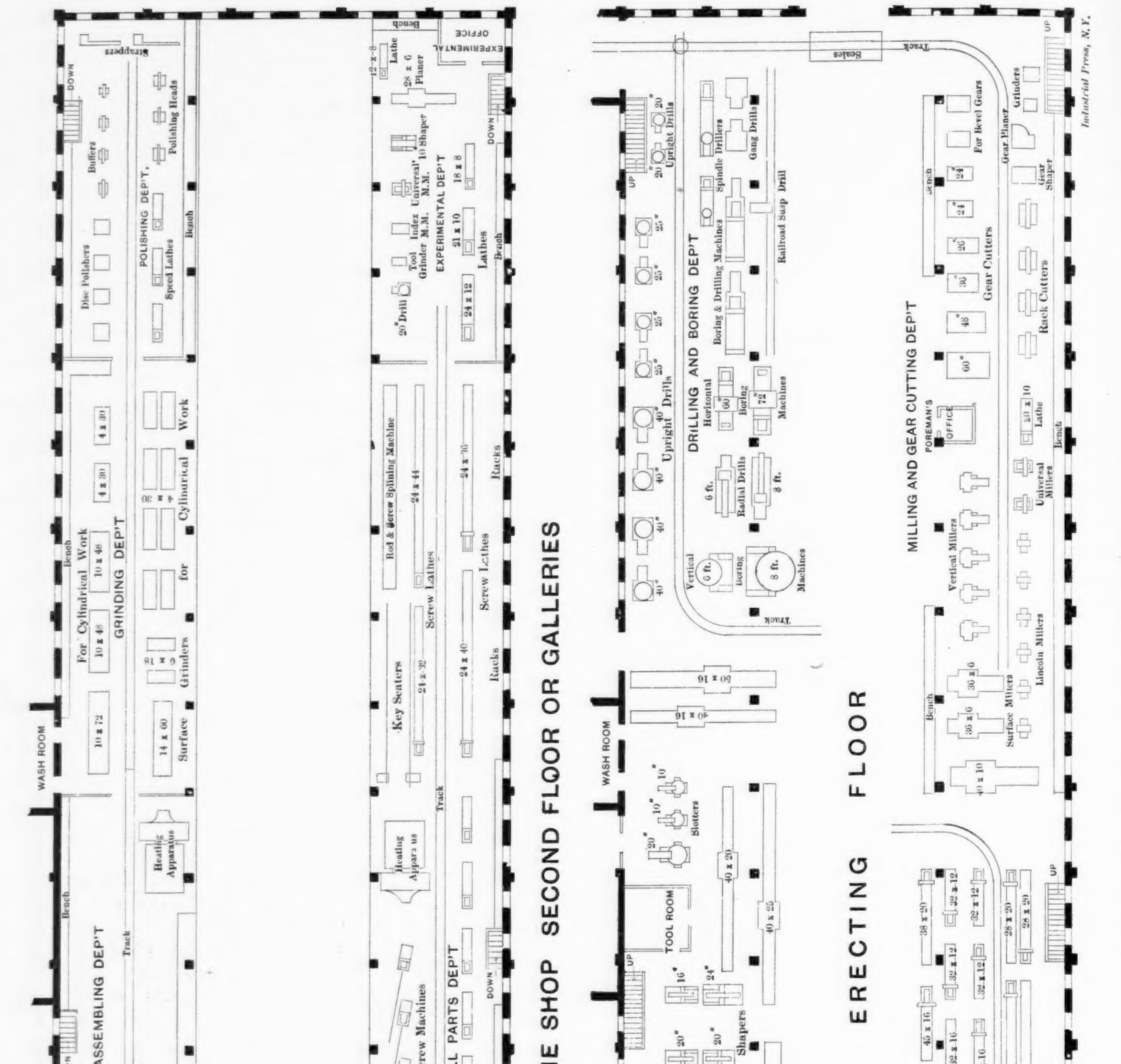
In all the operations of manufacturing, from the very conception of the idea that we *will* manufacture, to the final marketing of the product, if we are to expect success, either in the building, the equipping, or the management of the manufacturing operations of such a varied and complex nature, we must first of all have a well-conceived, well-matured, definite and comprehensive *plan*. If this is not so we shall find the various component parts of our fabric disproportioned to each other. One will be of too great capacity and another of too little; one portion will be an unnecessary expense which will absorb the profits of another; one will be pushed while another is neglected; and so on until the whole establishment is in such a disjointed, disproportioned and inefficient condition that success either mechanically or financially is impossible. This is very forcibly shown in cases where a business that "ought to pay" seems to drift along from year to year with scarcely any advance in methods or profits to its owners. Another man takes charge and perhaps astonishes everyone by his seeming extravagance, but gradually order comes out of chaos, the expenses which at first staggered the good old conservative directors begins to tell and in due time everything is in proper condition, every portion of the concern does its allotted part, each in harmony with the others, everybody is cheerful and satisfied, better work is produced and the stockholders are getting their dividends. Why? Simply that the man is master of the business and works with a well-conceived plan. He knew from the beginning just what would be the result; he was not afraid to make radical changes; there was no patchwork about it. Every portion of his plan was carried out in its entirety. Two different parts do not make a complete whole, and to have several plans in mind and then attempt to carry out a portion of each is but to invite failure. And the invitation is usually accepted. This is also true even in regard to minor operations in the same line. We must get such a grasp of the complete idea and plan in all its details that "from the beginning we can see the end." One of our most successful designers of machinery always seemed to be a good deal of a laggard during the first stages of a new design and would draw and sketch and measure in what seemed a very desultory sort of a way. When remonstrated with for what "the boss" thought was wasting time, he used to say, "I don't wan't to make my drawing until I can shut my eyes and see the machine working." The complete conception of the design as it gradually forms in the mind is what is needed. And when a man had the ability to thus "see through" the whole design, the "working up" of the various component parts is to a great extent matters of mechanical detail only.

So it is, or should be, in planning manufacturing operations. We must see the end from the beginning. This applies with peculiar force in the alterations of or additions to plants already in existence, whether it be the changing on account of a different product to be manufactured, or of enlarging so as to increase the product. The plan should be comprehensive and provide for possible enlargements in the future, so that as each successive change is made we get nearer and nearer to the ideal of a completed structure that will be a credit and not a continual "eye-sore." Not only in appearance is this the proper method, but in the utility of the improvements made, and this again in proportion to the expense incurred. If any "piece-meal" plan is adopted from time to time the result will be not only a failure to get the greatest accommodation out of the improvement, but to do so at an expense which is frequently lost by subsequent alterations of such a nature as to compel us to tear down a portion of the former work. And this process is repeated again and again until the expense of successive changes, additions and alterations will have cost more than to have built the whole structure new. Beside this we have a mongrel structure in which "the last state is worse than the first." It is frequently better to make new things than to patch up old ones; ofttimes it is cheaper also. And this lesson may be followed through all the operations of manufacturing with good results to the reputation of the man who is responsible for the plans as well as the success of the establishment and the dividends to the stockholders.

It was from considerations such as these that in the first article (printed in the October number, 1902,) on Construction, it was pointed out how the capacity of our manufacturing plant might be economically increased and at the same time work along the same general lines so that the enlarged structure would be but an extension or expansion of the original plan.

In planning the relative location of the different departments of our machine shop in which are placed the several classes of machines it is necessary to so arrange them that when once the material, as iron castings or other heavy

* Supplementing the series upon Machine Shop Design, begun in the October, 1902, number, and ended in May, 1903.



Arrangement of Tools and Departments in Model Machine Shop, previously Described by the Author.

stock, comes into the shop, it shall pass in as nearly as may be a continuous line through the shop from its rough state to its place in the erection of the machines to be built with little or no "retrograde movement" or other unnecessary handling or similar expense. Light and easily handled stock is not subject to these conditions to such an extent, and may be handled on the upper floors as its transportation from place to place is easily effected by the tram cars, trucks, etc., on the level, and these run upon elevators, and carried to the various floors where they are needed for the different operations upon them, or to a finished parts storeroom, where they may be kept until they are wanted for the assembling of a complete machine. In our case, however, having but two floors, quantities of small work may be packed in trucks, cars or boxes and from the front gallery lowered to the ground floor by the traveling crane. In the same way stock or finished parts may be brought up to the gallery floors.

The plans accompanying this article show both the ground, floor and the gallery floors, with the location of all the machines selected to equip the shop, arranged as is thought best for the easy handling of the stock and the convenient performance of all the necessary work of machining, erecting and shipping. The machines are all shown drawn to scale, and with sufficient space around them for readily handling the stock and the machined parts.

The main floor is divided into five departments, namely, the planing, drilling and boring, heavy turning, milling and gear cutting, and the erecting departments, all located as shown on the plan.

Usually the first operations on nearly all castings and on many forgings is that of planing, this being particularly so with the heavier stock. Consequently it is advisable to locate the planing department near where this class of stock can be the most readily received into the shop from the foundry or from the forge shop. As by far the larger amount comes from the foundry the point nearest that department is where the planers should be located, so as to save distance in conveying material, and consequent expense. Our tram track leading from the foundry to the machine shop brings castings to a point nearly under the traveling crane (by which they are readily placed upon the planers on each side of it), or directly under it, by which it conveniently serves the large planers located in the erecting space just inside the row of columns. An overhead trolley delivers castings to the other planers in the row arranged at right angles to the shop as they are taken from the foundry cars, or carries them, when planed, to the tram track and thence by the traveling crane to any part of the shop where they may be needed, generally to the tram track laid through the drilling and boring department, or to the large machines of this class located within the reach of the traveling crane inside of the columns. This overhead trolley may be operated by hand hoists, or by compressed air, but preferably it should be of the type carrying a small electric motor by which it is very quickly, efficiently and conveniently operated. There should be at least two of these hoists on the trolley track, which should extend from the front end of the shop down to and over the tram track in the drilling and boring department.

It should be explained that in laying out the positions of the planers the outline shown includes the extreme run of the planer table, hence there is more space at the ends than would appear at first glance. In locating the planers with reference to each other they are placed at equal distances of five feet between tables without regard to the front or back, so as to give free access to both sides when the operator is putting on, setting or removing work. Those of the larger planers are located parallel with the length of the shop. It will be best to drive these with electric motors. The other planers, of such sizes as will accommodate the usual variety of work, are located according to the space available. Much of the medium sized work may be done on long planers very economically by filling the table with as many parts as it will hold, and running through the lot with a long cut, as for instance, with lathe heads or carriages, which may be planed in lots of ten to fifteen much cheaper than a less number on a short planer. The two planers near the wash room are convenient for comparatively large work where a short table is required. The other planers are arranged in pairs facing each other so as to be convenient for one man to run two planers. One man can easily run the 60-inch and the 72-inch planers.

In connection with the planers are located the shapers and the slotters, as shown in the plan. These are also served by the overhead trolley as noted above, and work from them, or from the planers may be thus conveniently moved to the drilling and boring department unless the parts are so large as to make the traveling crane necessary.

Next in the order of work is usually that of boring, either in vertical boring mills, horizontal boring machines, radial drills, etc. Therefore this class of machines will naturally come next to the planers, and on the same side of the shop, in the drilling and boring department. The vertical boring machines are of the usual type in which much of the large work, such as pulleys, balance wheels and many other heavy parts are much more readily handled than upon a lathe. The horizontal boring machines are those with the low, traversing table, and elevating head and tail stocks, while the horizontal boring and drilling machines are those with a stationary head and an outer support for the boring bar, and a vertically adjustable table supported by two vertical screws. The first is adapted to heavy work, while the latter handles that of medium weight. The so-called railroad suspension drill is one provided with a perfectly level track upon which long beds, as lathe beds, may be supported on rollers and run to any desired point in their length for drilling and tapping. Assuming that there will be hollow spindles required, two spindle boring machines are provided. These may be of the horizontal cylinder type for the purpose of feeding, where only one tool is used, or with a heavy turret and slide when more than one tool is required. Two gang drills are provided for jig work where medium or small sized holes are needed. Next to the wall is a row of ordinary upright drills of the capacity indicated. Where necessary, small jib cranes should be attached to the columns for use at individual machines, or for a pair of machines.

The heavy turning department, on the opposite side of the shop and at the front end, contains all lathes of 28-inch swing and upwards. Also, the heavy turret lathes for cast iron work and the larger parts of steel or other material. Here are also the vertical chucking machines, which are in many cases to be preferred to those of horizontal type. The lathes of 38-inch swing and upwards are placed inside of the row of columns so as to be served by the traveling crane. Nevertheless, small jib cranes attached to the columns and operated by hand will be found very useful for a number of the other machines. The cone-turning machine should be arranged to turn and crown all the steps of a cone at once. This and the pulley-turning machine are located convenient to the vertical chucking machines. Two shafting lathes of 28-inch swing and 44-feet beds are provided. In locating the lathes a space of four feet is left between the ends so as to give free access to any part of the room. Material is brought in on the tram track, one end of which extends out under the traveling crane. The heavy turret lathes and the vertical chucking machines will handle much of the work frequently done in the engine lathes and do it much quicker, thereby saving the number of the latter to be set up.

Next in order is the Milling and Gear Cutting Department. Here surface milling machines are provided for large surfaces, while smaller surfaces are taken care of by the six plain, or Lincoln millers. Two universal millers do the more complicated work and a small lathe is put in as a convenient machine to save going to another department for small and simple jobs of turning. The five vertical millers will do a large quantity of work very accurately and a better advantage than planers could do it, and at the same time at a much less cost for labor, as is the usual result with milling machine work. Six gear cutters are provided for spur gears, and two for bevel gears, while a special gear shaper and a gear planer will do the work required to be particularly accurate. Four rack cutters will usually be a proper proportion to the above. While the cutters for these machines are made in the general tool room, two grinders are provided so as to keep them in order in the department where they are used.

A convenient extension of the rear tram track furnishes means to bring in and take out work.

The gallery floors are divided into six departments, namely, Small Parts, Grinding, Polishing, Small Parts Assembling, Small Parts Store, and Experimental Departments. A tram track connects them all, passing through the cross gallery at the front end, under a traveling crane, by which any machine, car, truck, or lot of stock may be quickly transferred to or from the main or ground floor.

The Small Parts Department is the largest of the six and contains six turret lathes for making steel work from the bar, and four automatic screw machines for smaller work and for such special screws as may be made in the shop more economically than they can be purchased. A line of engine lathes of the sizes given on the plan handle such small work as requires to be turned on centers. Long lathes for turning and threading leadscrews and similar work are provided, as is also a machine with a traveling head for milling the splines in long rods or screws, and two small key-seating machines for milling semi-circular key seats. Racks for bar stock are provided in the front gallery and near the screw lathes for stock and for finished work.

The Grinding Department and the Polishing Department are for obvious reasons placed as far from the other work as possible. Much of the cylindrical work is sent to the grinding room to be reduced to perfectly cylindrical form on wet grinders and does not require any polishing finish. For this work three large, two medium and eight small grinders are provided. One large and two small dry surface grinders are arranged to take such small parts as require this treatment.

The Polishing Department as now known in connection with a machine shop is somewhat new in this class of machine work, but its importance and efficiency is becoming more recognized as its usefulness is being demonstrated. Four disk grinders or polishers are provided for small or medium sized flat surfaces, and work direct from the planers is quickly polished to a fine finish and quite true. Three speed lathes are expected to do all the small cylindrical work that has not been ground. Work requiring a bright buffed finish is taken to the four buffers, while irregularly shaped parts are polished on the three polishing heads or on the two belt, or strapping machines. This room, of course, enclosed as tightly as possible to avoid the difficulty of floating particles or grinder's dust passing to the other departments. Nearly all of this trouble may be prevented by a small exhaust fan connected with hoods at each of the machines by a suitable main pipe and branches, by which the dust is discharged in the open air, or a proper receptacle. This has the additional advantage of saving the eyes of the workmen from much annoyance and discomfort.

Small parts when completed are taken to the Finished Parts Store Room, which is located in the front end of the shop and furnished with shelves arranged in alcoves on one side of the room, while the opposite side is reserved for somewhat larger parts or collections of parts as may be necessary. This space should be fitted up to suit the particular kind of work, and may be in broad shelves running lengthwise of the room, or in alcoves as on the opposite side.

Between this room and the grinding department is the Small Parts Assembling Department, in which it is intended to assemble groups of small parts, as for instance, the parts comprising the apron of a lathe, or similar work. If the parts are accurately made no machine work will be here needed, although a small engine lathe might be a convenience at times. Bench vises and the usual assembling "jacks" comprise most of the necessary fittings.

In the back end of the opposite gallery is located the Experimental Department, where small and medium sized experimental work is to be done. It contains, as will be seen in the plans, a variety of machines suitable for experimental work, so as to render it unnecessary to go to any of the other departments for anything except large turning, planing and gear cutting. Such a department is a necessity to a shop aiming at making progress and keeping up with the times, as work of this character costs too much if done in the regular tool room, and it is not only an awkward but expensive matter to place it in any other department.

Along the front of each gallery is an iron railing 32 inches high, that on the front end gallery having an easily removable section 12 feet in length, for convenience in passing work to and from the gallery by the traveling crane.

The Foremen's Offices, the Tool Distributing and the Finished Parts Store Room are sheathed up with ⅞-inch pine to the height of 44 inches, above which it is enclosed with wire netting of 1-inch mesh and 4 feet in width. This form of construction affords an ample enclosure and does not materially impede the light. The doors should be provided with spring locks, and workmen generally not allowed in these enclosures except by permission.

* * *

A MODERN OFFICE BUILDING.

The accompanying cuts show the new office building lately completed by the American Blower Co., Detroit, Mich. The building is devoted entirely to the company's offices and is a model of convenience and unusually attractive in appearance. It was intended that the building should represent the highest development in office construction, both architecturally and in its heating and ventilating and other equipment. It is from designs by Malcomson and Higginbotham, Detroit, in adapted Colonial style.

The building is faced with standard size paving brick in various shades of brown, laid in dark mortar and with Flemish bond. The trimmings are of buff Bedford limestone and plate

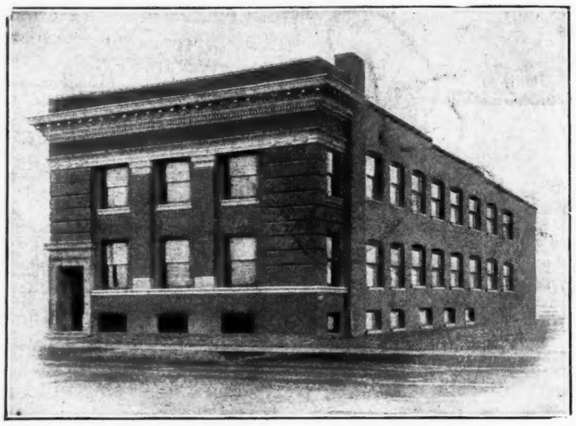


Fig. 1. Office Building of American Blower Co.

glass windows give the best possible lighting effect, especially in the drafting room. The broad pilasters and heavy cornice in front give an imposing appearance.

The first floor is occupied entirely by the different commercial departments, while the second floor is used by the engineering and drafting departments. The basement is used for the storage of catalogues, letter files, etc. A small building on the roof is used for blueprinting, and as a dark room.

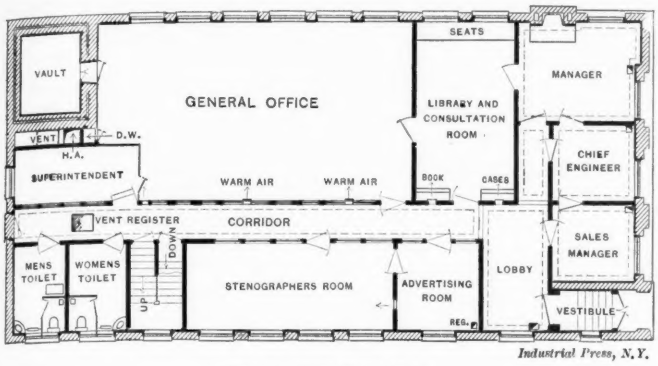
The interior finish of the first story is Flemish oak with natural oak floor. The second story is finished in stained Louisiana cypress with maple floor, which affords a pleasing contrast. The decoration of the library and consultation room is more elaborate and includes a wainscoting, decorative frieze, and wood cornice, in harmony, however, with the general design of the building.

Every modern equipment is provided for the building, including electric lights, annunciator bells, dumb waiter, an outside telephone system, and an independent inside or house system connecting all departments in office and shops.

The main interest in the equipment, however, is in the mechanical system of heating and ventilation. As the manufacture of heating and ventilating apparatus forms a large part of the American Blower Company's business, this part of the office equipment naturally received due attention, and an even, pleasant temperature and thorough ventilation are secured without drafts.

The apparatus is located at one side of the basement, as shown in the accompanying plan. The fresh air enters the building through the basement window *F* and by means of the fan *A* is drawn over a coil of pipes *E*, called the tempering coil. The steam pipes of this tempering coil are just suffi-

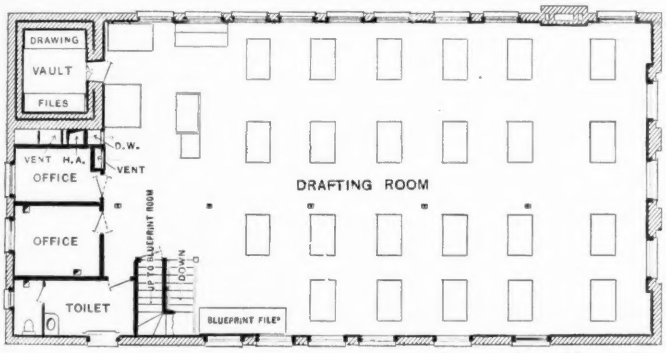
cient in number and length to heat the volume of entering air to a temperature of 65 or 70 degrees F. The fresh air is then drawn into the fan and forced over another heater *D*. This is the main heater and is designed to heat the air to about 140 degrees. Beyond the heater is located a large brick chamber *G* called the plenum chamber. This serves as a reser-



Industrial Press, N.Y.

Fig. 2. First Floor Plan.

voir for the heated air and from this chamber the air is conveyed by galvanized iron pipes *H* to the various offices. Under the main heater *D* is a passage or by-pass as it is called, which permits a part of the air from the fan to pass under the main heater coil and into the plenum chamber. This passes into the lower section of the plenum chamber, which is separated from the upper part. Thus the plenum chamber is divided into two parts, the upper chamber containing hot air at approximately 140 degrees and the lower section tempered air at 70 degrees. As shown by this sectional view, each individual pipe leading off to the offices above, has two connections to this plenum chamber, one branch to the upper section and another to the lower. In each main where the pipe divides into these two sections, there is located a set of double swinging dampers, or mixing dampers. Each set of these dampers is controlled automatically by a diaphragm valve which is part of a system of automatic heat control furnished by the Johnson Electric Service Company of Milwaukee, Wis. These valves are operated by compressed air, which is supplied by a small air compressor, located in the basement, and operated by city water pressure. In each office is located a thermostat which can be set to control the room tempera-



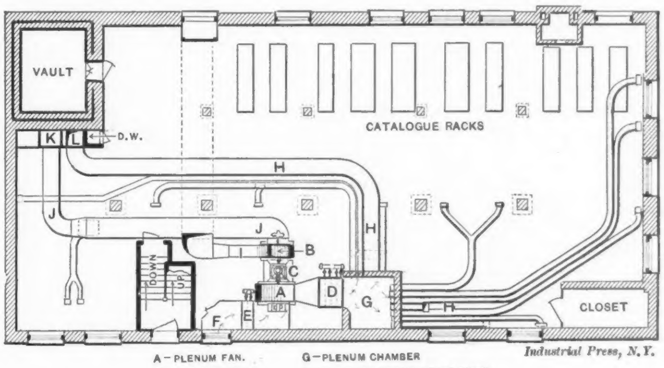
Industrial Press, N.Y.

Fig. 3. Second Floor Plan.

ture at any desired point. These thermostats work upon the principle of the unequal expansion and contraction of brass and steel, and are all connected by head pipes, of about 3/8-inch bore, with their respective diaphragm valves. On the expansion or contraction of a piece of brass and steel in the thermostat, air pressure is admitted or cut off from the diaphragm valve and the mixing dampers are swung one way or the other as the case may be. It will be noted that these mixing dampers in swinging do not cut off the flow of air, but simply vary the proportion of hot and tempered air as controlled by the thermostat to maintain a constant temperature in the room. Thus a constant flow of pure air of the proper temperature is maintained at all times. Under the tempering coil there is also a by-pass similar to the one under the main heater. This by-pass is fitted with a swinging damper which is controlled by a thermostat placed in the upper part of the plenum chamber. Thus if the air in the plenum chamber becomes too hot, the thermostat opens the damper under the tempering coil and allows the entering air to pass under the tempering coil, instead of through it. The air is admitted to each room at a point about eight feet above the floor.

Another unique feature of this plant is the exhaust fan which is direct coupled to the same engine which runs the heating fan and which draws the impure or vitiated air out of the building. Thus while one fan is discharging pure warm air into the building, the other fan on the same shaft is drawing out the impure air. This is the main feature of mechanical ventilation which has brought it into such general favor during the last few years for use in public buildings.

In each office on the first floor there is located an ornamental register face at the floor line, opening into the corridor which extends through the center of building. The air is thence drawn down through the large register in the floor at the rear



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A—PLENUM FAN.
B—EXHAUST FAN.
C—ENGINE.
D—HEATER COIL.
E—TEMPERING COIL.
F—FRESH AIR INLET.
G—PLENUM CHAMBER
H—WARM AIR DISTRIBUTING PIPES.
I—EXHAUST DISCHARGE DUCT.
J—EXHAUST INLET DUCT.
K—VENT FLUE.
L—WARM AIR FLUE.

Fig. 4. Basement Plan, showing Heating and Ventilating Apparatus.

of the corridor and after passing through the exhaust fan is forced outside the building. The air from the drawing room and second story offices is drawn through the flue at side of vault.

The condensation from the heating apparatus is returned to a Webster feed-water heater located in the engine room of the factory, by means of the Webster vacuum system which was furnished by the American Engineering Specialty Co., of Chicago. This same system handles all the condensation from two other heating plants located in the factory. The advantage of this vacuum system is that it eliminates the back pressure from the factory engine, when using exhaust steam for heating and also removes the air from the heating coils and connecting pipes as fast as it accumulates, thus making the heating surface far more effective than it otherwise would be.

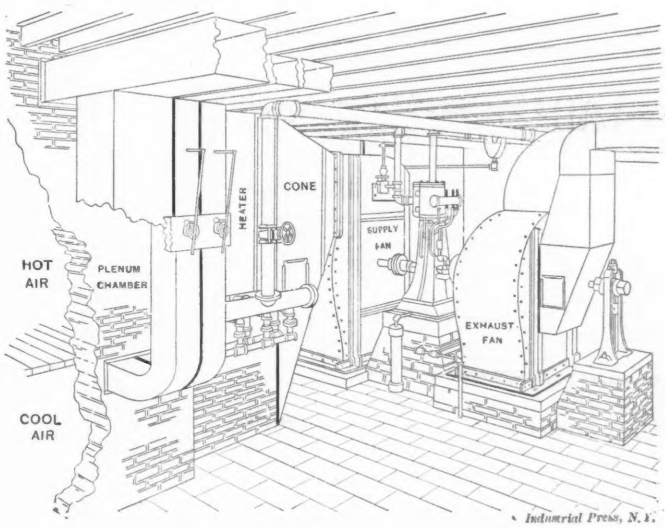

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Fig. 5. General View of Heating and Ventilating Apparatus.

Only one thing remains to be mentioned and that is the economy of this system. As the heating coils utilize the exhaust steam from the factory engine, which is brought into the basement through an underground conduit, and as the fan engine exhaust is also turned into the heater coil, the cost of operating is very small, and in fact practically nothing under the conditions, as the steam that is used for heating, would otherwise probably be wasted.

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MACHINERY is issued in three editions—the Engineering Edition, printed on coated paper throughout, each volume comprising 650 reading pages and forty-eight 6x9 data sheets—price $2.00 a year; the Shop Edition, printed on super-calendered paper, comprising 430 reading pages devoted to practical shop matter—price $1.00; and the Foreign Edition, which comprises the same matter as the Engineering but is printed on thin paper for transmission abroad—price $3.00 a year.

A NEW OLD ENGINE.

Several technical journals have recently published descriptions of an alleged new rotary steam engine, the principle of which, in its simplest form, involves the use of two revolving cylinders or wheels mounted on parallel shafts and working inside of a closely fitting case. One of the cylinders carries teeth, preferably two, which engage the same number of tooth depressions in the opposing cylinder. Both cylinders are geared so as to rotate in opposite directions and at the same peripheral speed, gears of the same diameter being keyed to the shafts outside the casing. This is necessary because the cylinders themselves are mutilated gears and can only transmit motion one from the other when the teeth are in engagement with the tooth spaces. Steam admitted into one side of the casing tends to rotate the cylinders, since the pressure on one tooth is unbalanced, the other tooth being shut away from the steam pressure by the periphery of the other cylinder. It is clearly obvious to anyone at all familiar with the construction of steam, air and water motors—especially the large class known as rotary engines—also with positive pressure blowers, that the principle is anything but new. The device in question is simply a modification of the well-known Roots blower used for iron foundries, etc. But we can go way back of this invention and find one very similar. Seth Boyden of malleable iron and patent leather fame, invented a steam rotary engine working on the same principle, although not employing mutilated gears, and was granted a patent for the same October 31, 1831. In the description of the invention the following appears:

"Two teeth wheels are placed with their axles in sockets or supporters parallel and horizontal to each other and close together as the teeth will play free. The whole is inclosed in a case of cylindrical form, which holds pieces termed packing against the ends and opposite sides of the wheels to prevent the steam from passing the wheels without acting on them. This packing is pressed to the wheels by screws to close the vacancy made by wear. The steam is applied to the under side of the wheels, pressing forward on the teeth of each wheel opposite to each other, causing a rapid rotary motion, while the teeth on the side next each other from the pressure of the steam. In this situation the steam presses outward on a surface equal to the depth and width of two teeth while the teeth come in behind each other, exposing the surface of only one, giving a power equal to the pressure of the steam on the tooth of one wheel. A connection is made to one of the axles through the case to communicate their motion to whatever it may be applied."

* * *

The application of electricity as a motive power for machine shops has been an evolution rather than a revolution, and, except in special instances, its use is steadily superseding that of steam, compressed air, hydraulics, rope drive, or combinations of these powers. In the past ten years the use of electric motors in shops has risen from a few incomplete and scattered cases to the present employment of about 600,000 H. P. regularly supplied by electricity.

A large manufacturing concern states that exclusive of those used for railways, automobiles, elevators, and fans, there are over 60,000 motors, ranging from $\frac{1}{8}$ H. P. to 2,000 H. P., in daily operation in the United States, supplying over one million horse power, and representing an investment of about twelve million dollars.

It is recorded that in one instance where thirty steam engines of 1,375 total horse power were supplanted by fifty-seven motors of 1,065 total horse power, for machine shop driving, the average daily saving in steam was 41.6 per cent., of combustibles 32.2 per cent. (coal saved 20,000 pounds). In other cases electric driving has reduced by 50 per cent. the cost for engineer, coal, and water; the fuel account 20 per cent., the cost of power 44 per cent. The gross saving was 30 per cent. with direct connected motors, and 22 per cent. with belted or geared motors.

* * *

SYSTEMATIC PRESENTATION OF PAPERS.

In arranging for the recent meeting of the American Institute of Electrical Engineers at Niagara Falls a plan was adopted that was productive of good results and that we would commend to the American Society of Mechanical Engineers as a desirable means for enhancing the value of papers presented at its meetings. The plan consisted in placing in charge of a member who is a specialist in a given subject the preparation of a programme of papers on that subject. The result is a much more complete presentation of the topic under discussion than would be possible in any other way. It is of the greatest advantage to engineers to have complete data gathered in one place for convenient reference, and the subject treated from several different standpoints. It is seldom that an author can write comprehensively from his own experience alone, and a man seldom has time or opportunity to draw information from various sources and to present a paper giving a broad and general view of a subject. Such papers have been given at meetings of the A. S. M. E., notably by Prof. Thurston, on topics like superheating, steam turbines, etc. But as a general thing any single paper is more likely to either give the results of one man's experience or else to be more or less one-sided in its treatment. By having several related papers, however, written in accordance with a general plan outlined by a competent authority, they would be of greater value to all concerned, just as they have proven to be in the case of the Institute of Electrical Engineers.

Should it happen that a subject were to be treated on which there were very few available data, the plan would still work out well, for the person in charge could outline a series of tests which various colleges would doubtless be glad to carry out and the work would thus be conducted on a systematic basis. It is usual, under the present order of things, for a college laboratory to undertake a series of experiments so extensive that it is impossible to complete them in any reasonable time, and in consequence they do not bring out the points upon which information is desired in anything like a complete manner. It would be an improvement if some of these tests, at least, could be under the guidance of one central ruling hand.

* * *

This number of MACHINERY begins the tenth volume of the paper. A copy of the index for the past year will be sent free to any subscriber asking for it, and in writing kindly state whether the index for the Shop Edition or for the Engineering Edition is desired.

THE GAS TURBINE.

In connection with a discussion on the steam turbine at the Master Mechanics' convention at Saratoga, Prof. Hibbard of Cornell University announced that there were prospects of developments in the field of the gas turbine at the General Electric Company's works, Schenectady. A gentleman, who recently received an advanced degree at a Western university in virtue of a very thorough investigation on the subject of the gas turbine, is now in the employ of the General Electric Company, and the inference is that he will have at his disposal the extensive facilities of this company for conducting experiments that may eventually lead to a successful gas turbine. This gentleman is Mr. Sanford A. Moss, who has made a special study of the subject of gas turbines since 1898. He received the degree of Master of Science at the University of California and has also studied at Cornell University, specializing upon the same subject—that of the gas turbine.

The great thermodynamic advantage of the steam turbine over the steam reciprocating engine is that there is no condensation and re-evaporation through contact with metal surfaces which are alternately heated and cooled. The only condensation in a steam turbine to amount to anything comes from the conversion of the energy of the steam into work. In the gas turbine there is, of course, no condensation to enter into the question, but there is an opportunity for another and more important gain through the abolition of the water jacket. It is a singular fact that the turbine is theoretically and probably practically capable of effecting a saving over the reciprocating engine, whether used with steam or with heated air, but because of entirely different reasons in each case.

It is well known that the efficiency of the gas engine depends mainly upon the degree of compression pressure attained in the working fluid. When operating upon the Otto cycle the gas and air are compressed to as great a pressure as practicable and then are exploded, giving a still higher pressure. This same process can be employed in connection with a gas turbine and has been advocated for that purpose. Under this plan the air and gas would be compressed and exploded in a chamber lined with refractory material, and would then discharge through a diverting nozzle and impinge against the blades of a turbine wheel, as in the case of the De Laval steam turbine. The diverging nozzle would act as an expansion nozzle, to reduce the pressure of the gases to atmospheric pressure and convert their potential energy into kinetic energy before doing work upon the wheel. The discharge would occur in puffs, an impulse being given as often as an explosion occurred.

Another method of accomplishing the result would be to have the combustion element burn continuously in contact with compressed air in a refractory chamber from which the heated air would discharge continuously through the expansion nozzle. The pressure in the chamber would remain constant under such conditions and the question of efficiency of the apparatus would depend solely upon the pressure that was attained through compression, as the relative amount of work done in an engine working upon this cycle does not depend upon the temperature of combustion. The efficiency of this cycle is not as high as that of the Otto cycle, but for turbine purposes would have the merit of giving continuous discharge through the nozzle instead of intermittent discharge. This plan of compression and then heating under constant pressure was employed in the well-known Brayton petroleum engine, one of the pioneers in the gas engine field.

The perfection of the gas turbine will not be an easy proposition. It will either have to be accomplished by individuals, working in a hap-hazard way through a long period of years, or by the concentrated efforts of some large firm like the General Electric Company. The latter plan will undoubtedly result in the quicker solution of the problem. One of the problems will be that of the temperature of the gas and its effect upon the metal of the turbine wheel. While the hot air will not come in contact with any of the bearings of the wheel, it is evident that the blades might not stand up to their work if subjected to a very high temperature. The fact that all bearings and wearing surfaces, however, would be removed from contact with the hot gases, would undoubtedly make the water jacket unnecessary.

HIGH-SPEED STEEL.

Practically all the makers of tool steel in this country and in Europe appear to have brought out under some fancy name a so-called "high-speed steel." Most of these steels, if not all of them, depend upon the influence of tungsten, chromium, molybdenum, titanium, etc., together with the heat treatment to produce a peculiar steel alloy which is actually harder when hot up to, say, a low red with some brands, than when cold. In fact some makes of high-speed steel can be filed when cold after they have once been used. Almost any one of these steels seems to be able to accomplish wonders when manipulated by its friends, but in the hands of the average user there is a variety of experience—good, bad, and indifferent—which indicates a great degree of variation in the same brands of steel, and it also shows the want of adaptability in toolsmiths to handle them. This latter is often the prime cause for want of success. The whole training of most toolsmiths has been to give them a horror of overheating tool steel, but many of the high-speed steels must be forged at a white heat. In fact the attempt to forge at the heat ordinarily employed on tool steel will result in failure. One brand we know of must be heated until the steel drips at the point and is then dipped in oil—pretty severe treatment, but it must be followed to get the maximum efficiency. Again there is all the difference in the way a comparative test of different brands is made. Suppose that one maker has sent a sample of comparatively small section and another has sent a larger and heavier section. The small section is at a disadvantage for slow speed and a heavy cut, as it does not have the strength to resist vibration; but at high speeds and light cuts it will ordinarily show up better than the heavy section, as its temperature will rise to nearer the effective working degree. The point is that almost all the leading brands have a critical working temperature which lies within comparatively narrow limits. The best results with high-speed steels are obtained in those shops which have selected some one brand and have stuck to it. They have gotten their toolsmiths and machine men educated to the peculiar characteristics of the brand used and know how to handle it. A change to another brand is usually unsatisfactory all around.

* * *

LEAFLETS AS SUPPLEMENTS TO CATALOGUES.

A practice that is coming into vogue with some machine tool builders, is to have cuts and descriptions of their various machines printed on loose leaflets of the same size as their regular letter paper sheets, one machine and description appearing on a leaflet. Whenever an inquiry is received regarding a particular machine, the letter of reply is accompanied with a leaflet, in the same envelope, giving the cut and description. This practice insures that the party receiving the letter will also get the description which he often fails of in some offices, because of the careless treatment accorded catalogues and other advertising literature in general. The practice is one highly thought of by purchasing agents of railways and large concerns. It saves them much valuable time in wading through catalogues, and it puts the desired data in convenient form for filing along with the letter quoting price, date of delivery, etc. The leaflets may be perforated for filing in a loose-leaf binder, but this is not essential as they are not intended to take the place of the regular catalogues, but are only supplementary to them.

* * *

In a paper upon the gaseous fuel problem read by Mr. Henry G. Morris before the Engineers' Club of Philadelphia, a strong argument is made for the development of by-products coke ovens. Taking figures for the bee hive ovens between Altoona and Pittsburg, we find that 20,000 tons of coke are produced per day, from which about 100,000,000 cubic feet of gas discharge into the air. This gas, if converted into power through gas engines, would represent 5,000,000 horse power hours, or the effort of about 104 gas engines of 2,000 horse power each. Manufacturers of gas apparatus are now offering to guarantee the production of a horse power hour for one pound of fuel—a result not at present attainable through the medium of steam engines and boilers, except by the most complex type of engine.

BOILER BRACING.—1.

CHARLES L. HUBBARD.

In laying out the braces for any given boiler the first step, whatever the type of brace to be used, is to determine the bounding lines of the area to be supported. From tests made it has been found that a steel tube two inches in diameter and of standard thickness will resist a pull of from 15,000 to 20,000 pounds, so that in the case of a cylindrical boiler only that portion of the heads above the tubes need to be considered in laying out the braces. If a boiler head could be made convex or "bumped up" to the extent of one-eighth of its diameter, as shown in Fig. 1, it would be as strong as any portion of the shell, provided it was of the same material

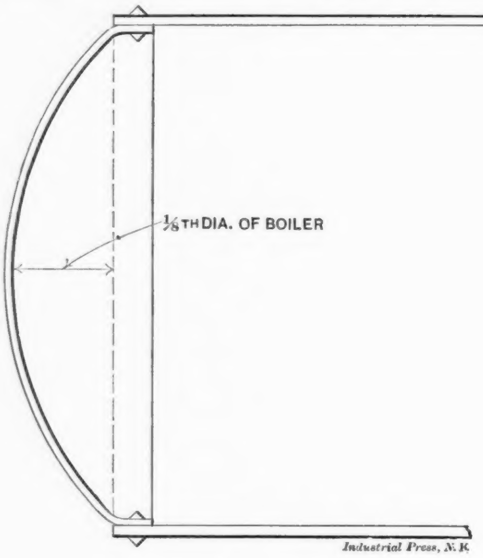

Fig. 1.

and thickness. It would be very difficult, however, to connect the tubes with such a head, so flat heads must be used and the pressure above the tube line must be carried by stays or braces.

In determining the area to be supported it is customary to consider the lower edge as bounded by a line drawn through the upper row of tubes, at a distance equal to one-fourth their diameter below the upper edge (see *A C*, Fig. 2). The remaining boundry line is evidently that formed by the upper part of the boiler shell. It does not follow, however, that the whole of this enclosed area must be supported by the braces, because when the head is flanged and riveted to the

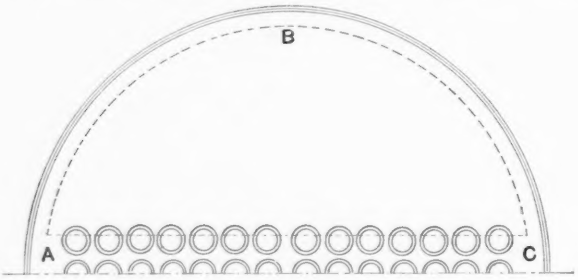

Fig. 2.

shell a portion of it becomes stiff enough to carry the pressure independently of the braces. The distance from the shell that it becomes self-supporting may be determined by the following formula:

$$D = \frac{4484 \times T}{10 \times P} + .5, \text{ in which}$$

D = the distance in inches.

T = the thickness of the head in inches.

P = the boiler pressure to be carried.

Refer to the diagram, Fig. 3.

Having determined the value of D for any given case the line *A B C* may be drawn in, giving us the area to be supported by the braces. If some form of diagonal brace is to be used, the number will be determined both by the size of the brace and the area to be supported. In case any of the solid steel braces like the McGregor or Huston are used the size of the brace will in general be fixed, and the number must be made such as will safely carry the total load upon the unsupported area. If crow-foot braces are used the size, and therefore the number may be varied somewhat. The actual supporting points are the rivets attaching the stays to the heads, and the spacing of these will depend upon the thickness of the plates and the pressure to be carried. The allowable maximum distance between the supported points may be computed by the formula

$$p = \sqrt{\frac{C t^2}{P}}, \text{ in which}$$

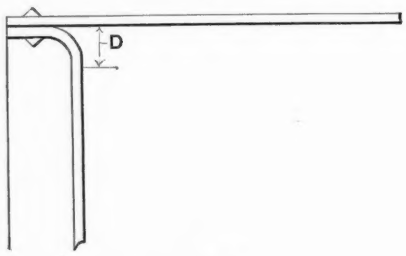

Fig. 3.

p = the greatest allowable pitch in inches.

t = the thickness of the plate in sixteenths of an inch.

P = the working steam pressure carried on the boiler.

C = 112 for plates 7-16 inch and under.

C = 120 for plates over 7-16 inch.

This applies only where the supported points are in equidistant rows, both vertically and horizontally. When the rows are not equally spaced, the greatest distance between supports may be taken for the value of "p," which will give a safe result in all cases.

In order to know the total load to be carried by the braces we must first compute the area of the supported portion and multiply it by the boiler pressure.

The area of this segment may be obtained from a table which can be found in almost any engineer's hand book, or may be computed in the following manner:

Carefully measure on your drawing by the means of a pair of dividers, the arc *A B C* (see Fig. 4), and multiply the same by one-half the radius of the circle. This will give the area of the sector *O A B C*; deduct the area of the triangle *O A C* and the result will be the area of the segment, *A B C*.

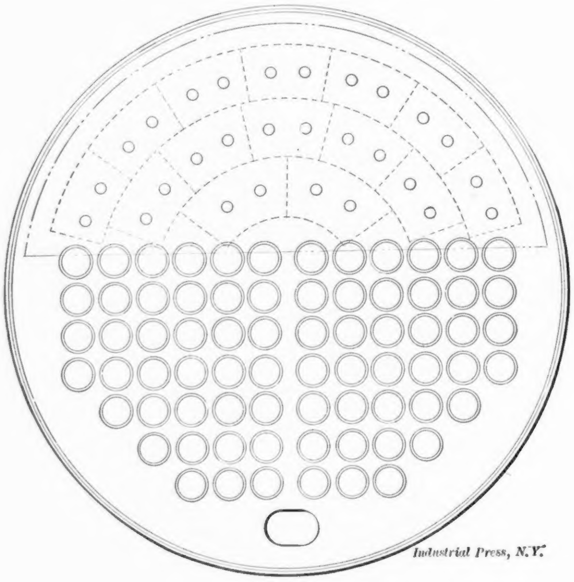

Fig. 7.

In crow-foot bracing the supporting points are usually arranged in sets of four, and are fastened to forgings known as "crow-feet." A diagonal stay with a forked head and pin connects each crow-foot with the boiler shell, to which it is fastened with two or more rivets.

A crow-foot joined to the boiler head with four rivets is called a double crow-foot, while if only two rivets are used it is called a single crow-foot. Single and double crow-feet are shown in Figs. 5 and 6, respectively. In the design of crow-foot bracing that portion of the head enclosed within the segment is marked off in points to be supported, the dis-

tance between these being limited by the value of "p" as found by the preceding formula. The points are then taken in groups of two or four as desired and tied to a crow-foot by rivets. (See Figs. 7 and 8.)

The load to be supported by any one brace is that due to the steam pressure acting on an area bounded by lines drawn on

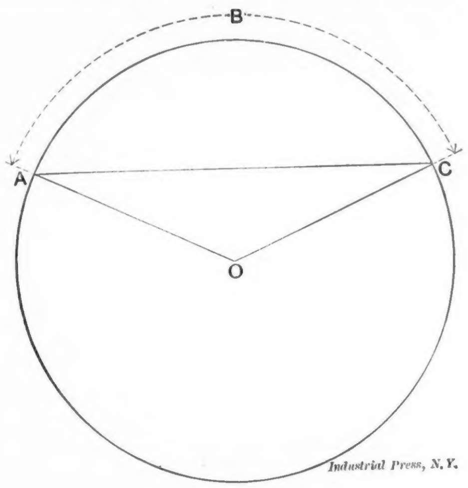

Fig. 4.

the four sides of the chosen group of rivets, halfway between them and the adjacent groups or other points of support as the case may be. (See Fig. 7.) The rivets should be spaced so that the total load will be divided among the different braces as evenly as possible. It is customary to compute the size of the brace carrying the greatest load, and then make the others of the same size for uniformity.

The "section modulus" for a section of circular form is

$$\frac{\text{area} \times \text{diameter}}{8}$$

We know from "mechanics" that
$M = R f$ in which
M = maximum bending moment,
R = section modulus, or moment of resistance,
f = maximum stress in outer fiber of the bar.

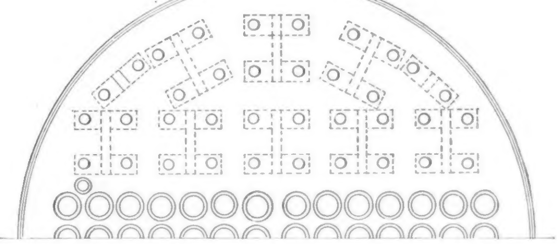

Fig. 8.

Substituting the values of M and R in the equations, and transposing we have

$$f = \frac{W L}{\text{area} \times \text{diameter}}$$

in which f should not exceed 12,000 pounds.

The crow-foot being a forging should not carry a load of much over 5,000 pounds per square inch of section at its weakest point.

The stays or braces are made of wrought-iron, as the fork which is attached to the crow-foot must be forged to shape. While wrought-iron should safely carry a load of from 7,000

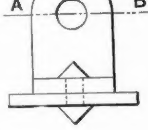

Fig. 5.

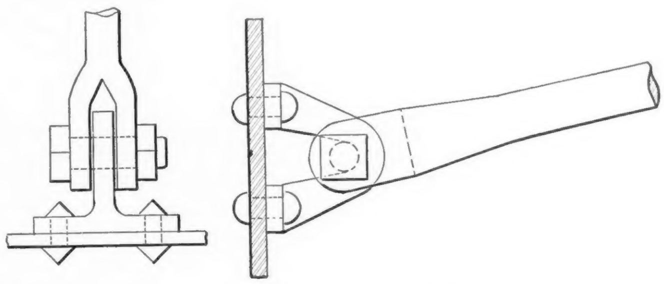

Fig. 6.

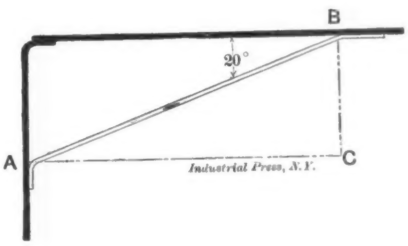

Fig. 10.

To find the size of rivets required divide the total load carried by the brace by the number of rivets in the crow-foot, to find the load on a single rivet and make the diameter such that the stress shall not exceed 6,000 pounds per square inch for steel. The diameter of these rivets should not in any case be less than three-quarter inch in diameter, owing to internal strains set up by riveting. The length of the bolt or pin between the supports is so short that the principal stress to be considered is that due to shearing; but for safety it may be checked for crushing effect and also treated as a

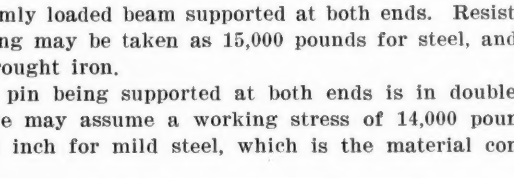

Fig. 9.

uniformly loaded beam supported at both ends. Resistance to crushing may be taken as 15,000 pounds for steel, and 12,000 for wrought iron.

The pin being supported at both ends is in double shear, and we may assume a working stress of 14,000 pounds per square inch for mild steel, which is the material commonly used.

If it is treated as a beam the maximum bending moment, $M = \frac{WL}{8}$ in which W is the total load on the pin, in pounds, and L the distance between supports in inches.

to 8,000 pounds per square inch, the fact that the brace contains one or more welded joints makes its strength somewhat uncertain and it is well not to count on much over 5,000 pounds. The end which is attached to the shell is flattened, and riveted in place, usually with two rivets, which may be of the same diameter as the pin, though never less than ¾-inch (see Fig. 9). The angle which the brace makes with the boiler shell should not in general be greater than 20 deg. Referring to Fig. 10, it will be seen that the pull in the direction of the brace is greater than the load which it supports perpendicular to the boiler lead, in proportion to the lengths of the lines $A\,B$ and $A\,C$. If the brace makes an angle of 20 deg. with the shell, we must multiply the load to be supported at the head by 1.07 to obtain the pull on the brace, and the required diameter must be proportioned accordingly. For different angles multiply by the following factors:

Angle.	Factor.
14 deg.	1.03
16 deg.	1.04
18 deg.	1.05
20 deg.	1.07
22 deg.	1.08
24 deg.	1.10
26 deg.	1.11

The common form of crow-foot and forked brace is being quite largely superseded by the various forms of solid steel braces, two of which are shown in Figs. 11 and 12. As this type of brace is of steel and has no pin to shear or weld to prove defective, we can count on a much higher tensile strength. As these braces come in stock sizes, having usually one square inch of sectional area after deducting that cut away by rivet holes, the method of determining the number

of braces is somewhat different from that already described. In this case we must first compute the area of the portion of the head to be supported and multiply it by the steam pressure, to get the total load. A solid steel brace should safely carry 10,000 pounds per square inch of section. From this it is evident that the total load divided by 10,000 will give the total cross section of the braces, and this divided by the sectional area of a single brace of the type to be used will give

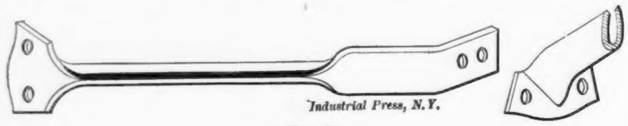

Fig. 11.

the number required. If the area to be held by the braces was in the form of a square it would be possible to locate them so that the exact number determined by a theoretical calculation could be used satisfactorily. But the space on the heads is in such form that this cannot be done, therefore it is necessary to put in enough braces to amply protect the whole, making the number actually required greater than the number determined by the calculation, as in some cases they must be

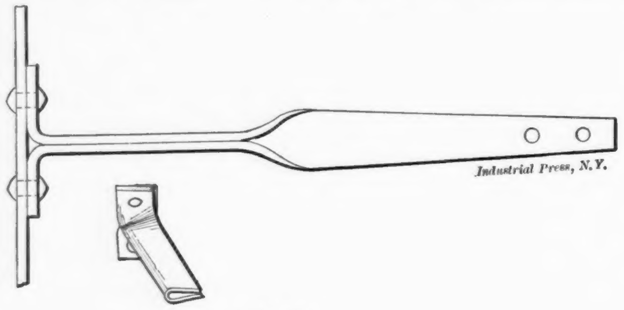

Fig. 12.

nearer together than the area exposed to pressure calls for. As this adds to the strength of the boiler there can be no objection to it. After the braces are all located, the greatest distance between rivets should be measured and the strength of the head checked by the methods already given.

A future article will take up the design of "through bracing" and combinations of through and crow-foot bracing.

* * *

MECHANICAL DRAWING AND THE SHOP.

In an address before the Eastern Manual Training Association's convention, held at Boston in July, Mr. L. D. Burlingame chief draftsman of the Brown & Sharpe Mfg. Co., Providence, considered the subject of mechanical drawing and its relation to practical shop work. He said that the drafting office has three distinct functions to fulfill. First, it must be an interpreter *to* the shop; second, an interpreter *of* the shop; and third, a recorder *for* the shop. There was a time when the designer, who had a rough conception of what he wanted to build, stood over the patternmaker until some box-like patterns were produced. With these as a skeleton to build on, the inventor continued to work out his design from "hand to mouth," cutting, changing, discarding, until the desired end was attained or until it was found necessary to start again. Now all this is changed and every piece must be fully and separately detailed, in many shops each on a sheet by itself, all particulars of oiling and venting oil holes, must be shown, grinding limits given, the depths of tapped holes figured. There must be an indication of where stock is to be allowed for fitting, and of the special kinds of finish on machined surfaces. All special tools used in manufacturing the piece must be listed below its name, and perhaps a list of operations given either on the drawing or in a separate list, and so on until it would seem that little was left for the machinist to do but to follow the instructions on the drawings without thought, or the use of his judgment. This may seem so to the draftsman, indeed it seemed so to me at one time, but when, after having a number of year's experience as draftsman, I went into the shop to work, I soon learned otherwise and felt like changing Hamlet's words: "There are more things in heaven and earth, Horatio, than are dreamt of in our philosophy," to read, "There are more things in the machine shop and foundry to learn, than are dreamt of in our drafting room." I have since had a growing respect for the machinist and for the importance of the problems *he* is daily called upon to solve.

In this office of interpreter *to* the shop the best results can be obtained by thorough system, by uniformity of practice, by condensing, by avoiding repetition, by keeping clear of complicated systems and unintelligible symbols. The drawings should be made to as large a scale as practicable, with figures and lettering bold and well separted from the lines of the drawing. All lines should be heavy for satisfactory blue printing. Pattern figures should not appear on the drawing but be marked in a blue print specially for the pattern maker, or in some cases a separate pattern drawing made. Third angle projection should be used in all cases for the sake of uniformity and directness. Finish should be indicated by some method that will not allow of misunderstanding.

On standard machines, each piece should be fully detailed. If on a sheet by itself, so much the better, it can then accompany the work through the departments of the shop and other work need not be held waiting for the drawings to use for other pieces on the same sheet. Stock parts should be used whenever possible and when used should be called for by a simple numbering system requiring but little clerical work and reducing the chance of error to a minimum. The drawings should be mounted for the shop on some suitable form of board. A thin metal plate with edges rolled as in tin work, to stiffen, makes a cheap, light mount and prints so mounted can be stored compactly. Orders should not be verbal, but should be written on printed forms and officially signed, books being used that produce multiple copies in such numbers as are required. All orders for new machines or tools should go through the drafting room before work is started in the shop. On standard lines of machines where lot after lot is built, some changes at least are required and these are often radical. In these cases drawings must be changed, records made complete, pattern lists revised, patterns altered or made new, and when all is ready, the shop notified. If urgent, the work can go along piece-meal as fast as ready.

There is a difference in practice as to whether the drafting department or the shop foreman should order castings, forgings and stock. In either case complete lists should be made up and kept corrected by the drafting department.

Before leaving this part of my subject I would emphasize the fact that the drawing is a means to an end and not the end sought; a point sometimes lost sight of by draftsmen and often lost sight of by technical students, a misconception for which the instructors may be sometimes responsible. It is natural no doubt in schools where making drawings is the work in hand, to make the drawing as such seem of paramount importance.

Admitting what has previously been said regarding the important place occupied by the machinist, you will also note the importance of the drafting department, as the interpreter *of* the shop. A friend of mine, one whose work has been unusually practical and successful, makes a constant practice of consulting with the machinists in whose judgment he has confidence, sometimes stopping his work and making a trip to a distant part of the works to get the shop man's opinion. It is not only the helpful suggestion that may come from such a conference, but the very statement of the case so plainly that it can be understood by another, may show to the designer a better plan, or show up a hidden fallacy. It is much better to have the suggestions and criticisms of the shop at the beginning when some benefit may result. Such consultations should be of much more frequent occurrence.

The drafting room should be so located as to be in the midst of the shop work if need be, even at some sacrifice of quiet and other advantages. It should also be in close touch with the pattern shop and foundry.

When making special tools, such as jigs, milling fixtures, etc., for reducing the cost of the work, the foreman or workman should not only be consulted but should usually have a deciding voice as to what should be made. He, having the tools to use, generally knows better than the draftsman what is needed.

The machinist and shop foreman being constantly with the

work, know which are the expensive operations, when there is difficulty in fitting, where the clearances are so small as to often become interferences. They have the machines to repair when they are worn or broken. Then why should their suggestions or opinions be disregarded or looked upon slightingly? Why should the spirit be bred of antagonism and distrust, until the shop man will not make suggestions for fear he will be snubbed or that his idea will be appropriated without credit? It certainly should not be so. I believe that it is not so in well-managed American shops to-day.

When I was abroad at the time of the Paris Exposition of 1900, I visited many shops in France and England. My observation at the time led me to believe, and my opinion was confirmed by the experiences of others with whom I compared notes, that the class distinction between the owner, the engineer (or designer) and the draftsman, on the one hand and the shop man on the other, is much greater abroad, especially on the Continent, than with us. It is there considered beneath the dignity of a technically-educated engineer, to listen to suggestions from machinists. The results of this feeling are sometimes very costly. In our American drafting rooms there is, in my judgment, a constant improvement in this respect, perhaps due to the increased percentage of American and Americanized draftsmen, thanks to the good work of our technical schools. At the best, enough attention is not paid this important function of the drafting department; that of conserving and making available the valuable information held by the shop.

A method I have known to be used with excellent results is for each foreman and responsible workman to have a blank stub book with suitable printed headings, paged and numbered. In this he writes all suggestions, taking out the perforated leaf and sending to the chief draftsman, keeping the stub as a memorandum for his own use. These are sorted when received, and those requiring immediate attention put into the hands of the proper parties to investigate, others are filed under the respective machines until time to build another lot, when they are considered collectively. The workmen are not only at liberty to use these books but are held accountable if they allow troubles to exist, lot after lot, on the machines they build, and do not report them. I would earnestly recommend that there be instilled into the minds of technical students the importance of taking advantage of the great mass of mechanical knowledge and the ideas stored up in the minds of the mechanics of the country, in the minds of the men who are actually doing the work, and that the students have it impressed upon them that if they become draftsmen, one of their important duties will be so to get in touch with the shop, as to make this knowledge available even though it may come to them in crude form from a mind not trained to analyze, to classify, and to put ideas upon paper. In other words, that they learn to be the *interpreters of the shop.*

In considering briefly the office of the drafting room as the *recorder for the shop,* we touch upon some of the more hum-drum, though not less important work, of tabulating, listing and classifying. Let me illustrate: Many thousand special tools accumulate in a large shop. Prominent among these are taps, reamers, drills and counterbores, cutters, gages, etc. When new designs are under way, it should be the draftsman's duty to adapt the design as far as possible to use such tools as are at hand. To accomplish this a complete record of all such tools should be kept and it is to the drafting department that we should look for dong it in a thorough manner, so that the record can be quickly referred to and depended on when used by either draftsman or shop man.

To again illustrate: A gear index of all spur gear patterns available to use under ordinary conditions arranged in order first by pitch, then face, then diameter will quickly tell whether a pattern for the required gear is made. These illustrations might be continued indefinitely. The card index is a great aid to such classification, as all entries are in order.

Another form of tabulating is in figuring tables for the shop. The draftsman's familiarity with figures and facilities for doing such work, often by the aid of the slide rule or calculating machine, makes the drafting room the natural and economical place for it to be done. The figuring of a table of all leads than can be obtained on a milling machine, with the regular change gears furnished, will illustrate. Those that have had to do with the cutting of spiral gears will appreciate the value to the shop of such a table.

There are many things to be preserved for reference that naturally find their way to the drafting room, such as trade catalogues, photos, copies of patents and technical journals. The treatment of these in indexing makes all the difference whether they are valuable—of growing value as time goes on —or as worthless as so much scrap paper.

* * *

UNIQUE HEATING AND VENTILATING PLANT.

An interesting heating and ventilating equipment was furnished the Twin City Telephone Co., St. Paul, Minn., some time ago, by the B. F. Sturtevant Co., Boston, Mass. In this installation special precaution was taken to purify the air supply. It has been demonstrated that about 90 per cent. of the trouble caused by imperfect contact in the switchboard connections can be prevented by thoroughly cleansing the air as it enters the building. Many experiments have been tried in the way of dry-cleaning by filtering through screens of wire and cheese-cloth or cotton-batting, but all such devices require frequent renewal, sometimes at considerable trouble and expense. By continued use any filter of this character must deteriorate and eventually become clogged, and in order to avoid the results of neglect it ought to be practically automatic. This point is essential in an air-cleaning system.

The action of the air-purifying and cooling apparatus adopted by the Twin City Telephone Co. consists in thoroughly saturating the air with water by passing it through a fine spray and afterward precipitating the moisture with the collected impurities and discharging it into the sewer. The water, which is taken up at high velocity and held in mechanical suspension, is extracted by centrifugal force by passing it through a series of tubes in which spirals are so placed as to give the air a whirling motion, causing the suspended particles, which are heavier than the air, to be thrown outward and brought in contact with the tubes, from which they flow through perforations to a drip-pan below.

The washing process imparts about 70 per cent. humidity at a temperature of 70 degrees Fahr. in the operating room. This is considered the most desirable for health and comfort and avoids the excessive dryness resulting with other systems of heating and ventilating which often require a humidostat to correct the defect. Moreover, in the summer time, with the temperature outside at 80 degrees Fahr. and with the normal temperature of the city water, the air delivered to the rooms can be readily reduced to 70 degrees.

The air after being tempered, washed and dried is blown by the fan through the reheating coils into the tempered air chamber. A mixing damper is placed with connections to both so arranged that the hot or tempered air, under the control of the Power's thermostat in the operating room, is mixed automatically to the proper degree, maintaining throughout the year a constant temperature in the room with uniform air delivery and humidity.

While such a system is practically a necessity in a modern telephone building, especially in cities where soft coal is burned, it is equally applicable to all public buildings, particularly in large cities where the air is laden with impurities and where the summer heat is almost unbearable. The time is probably not far distant when the marked advantages of such a system will be fully recognized and people will insist that they should be kept cool in summer as well as warm in winter.

* * *

A radial brick chimney was recently built in Newark, N. J., to accommodate an extension to the street railway power house. It is 250 feet high, 9½ feet inside diameter at the top and 13¾ feet inside diameter at the base of the circular column. The base is built of common brick, but the circular column is entirely composed of radial brick containing dead air spaces. The height of the base is 39 feet, and its width across "flats" is 21 feet. The base contains 160,000 common brick and the circular column 150,000 radial brick. The cost was $15,000.

THE RECONSTRUCTED SHOP OF THE BETTS MACHINE CO.

Machine shops built in these days and in accordance with modern ideas usually provide for expansion in some manner more or less consistent with the original plan of layout. This provision for future growth is very well illustrated, for instance, in the great plant of the Allis-Chalmers Co., at West Allis, Wis. Regarding the layout of this plant Mr. Edwin Reynolds is reported to have remarked, in a spirit of humorous exaggeration, that the wings of the main building could be extended indefinitely east and west, if need be, until they meet on the opposite side of the globe, and with that point reached, sufficient offset had been provided in the plan so that the extensions could pass by one another without interference and each make a complete circuit! But in the shop construction of the days gone by the probability of future growth usually appeared so remote or improbable that rarely was there any provision made for it. The result is that many a shop owner or manager has spent some bad days and nights trying to devise plans for extending his plant without tearing them down and building anew. And it has somtimes proved that an old plant can be remodeled into an up-to-date shop without tearing down the old shop or seriously disturbing the regular routine of work. An excellent illustration of an old machine shop converted into a modern plant with traveling cranes and other appurtenances for the economical production of heavy machine tools, is that of the Betts Machine Co. at Wilmington, Del., which forms the subject of the following description. The product of this well-known concern which was started by E. and A. Betts in 1860, is horizontal boring and drilling machines, planing machines, boring and turning mills and slotting machines.

The layout of the plant is given in Fig. 1. The plot of land on which the buildings stand, extends about 490 feet on Maryland Avenue, and is bounded on the sides by South and Foundry streets. On the back is the Philadelphia, Baltimore & Washington Railroad, part of the Pennsylvania Railroad system, which gives unexcelled shipping facilities by rail. The plan of the old machine shop is included in that of the present machine shop, an end and a part of a side wall being indicated by heavy dotted lines. The locations of the old office, tool-room, etc., are also indicated in the same manner. A new office has been built on the corner of the plot at the junction of Maryland Avenue and South Street. The first addition to the shop was made some four or five years ago. It consists of a monitor roof erecting shop and heavy machine shop, 234 feet long and 75 feet wide, which was built parallel to the machine shop and at a distance from it

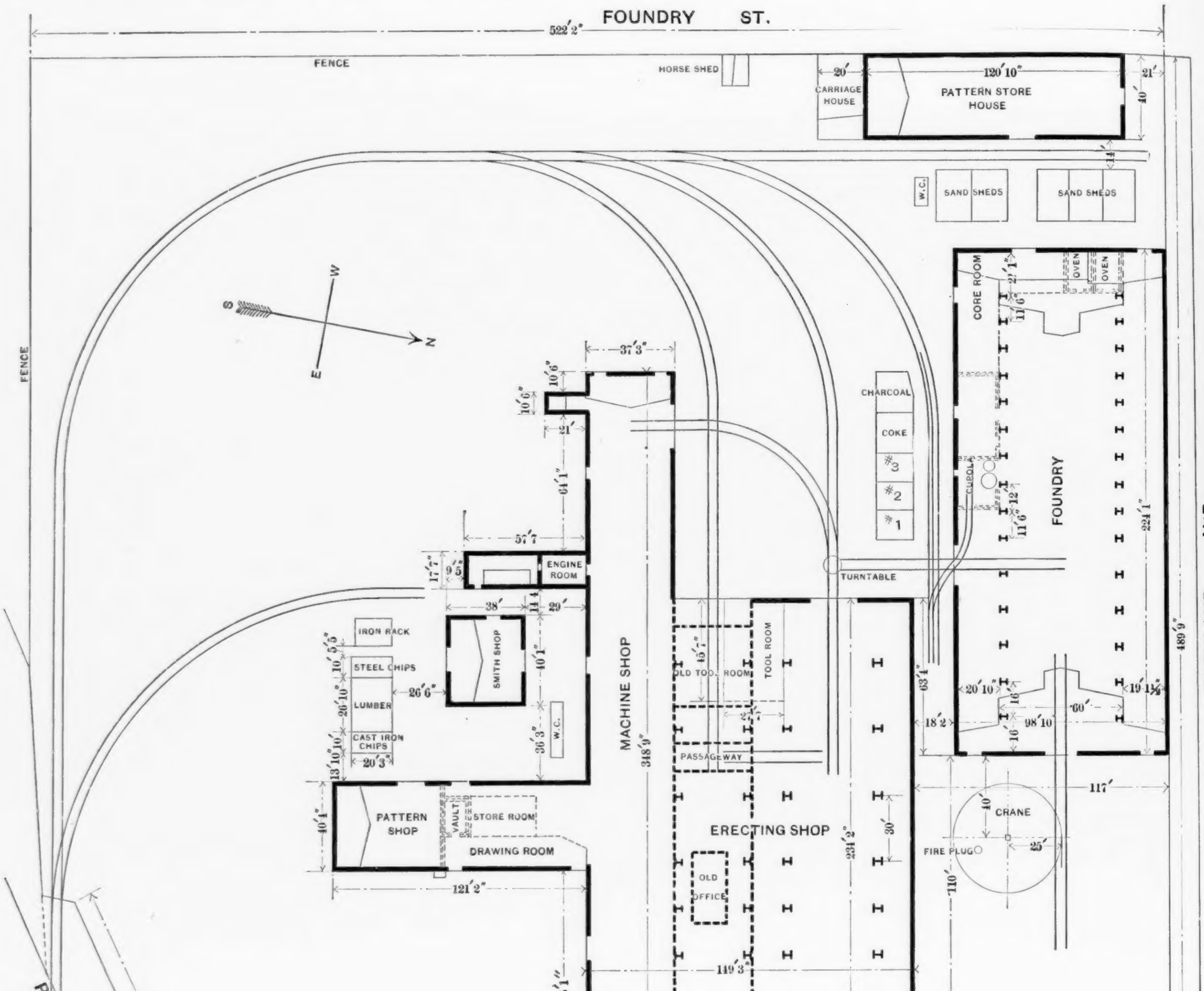

Fig. 1. Plan of Bett's Machine Co.'s Works, showing excellent Switching Facilities, etc. Note Outline of the Old Machine Shop partly indicated by Dotted Lines.

of about 38 feet. It extended through to the street so that all the available space in that direction was taken up, the street line forming, as it were, the point of departure. A covered passageway connected the new erecting shop with the old machine shop. This section is equipped with two Shaw traveling cranes, one 10 tons and the other 20 tons capacity. The span of the cranes is confined to the width of the monitor; the aisles at the sides being reserved for tools. There are no galleries, all the floor space being on the ground. The machinery in this part of the plant is driven by electric motors belted to line shafts. Electric current for driving the motors is supplied by the city power station. The heavy planers and other heavy machine tools are located in this part. Across the northeast end is a 10-foot planer embodying a new feature of design of which we shall probably hear more later. It has a platen 38 feet long and but 6 feet wide. The platen is made in two parts which may be uncoupled in the

building of the new part and the tearing down of the walls supporting the roof of the old machine shop proceeded without stopping the machinery. When it is considered that the portion of the roof to be supported was nearly 300 feet long and that it carried a heavy lineshaft in motion, some difficulty of the work will be appreciated.

The roof of the new erecting shop was built considerably higher than that of the first one so as to give more head room under the crane. This was required by the increasing sizes of machine tools built by the company. The head room under the hook is about 27 feet. It is a Pawling & Harnischfeger, capacity 20 tons. The lighting in this section is superb. A large proportion of the side area above the adjacent sections is given up to glass, as will be seen in the illustrations, Figs. 2 and 3. Reference to the plan, Fig. 1, will show that the new erecting shop, in effect, acts as a large monitor or clearstory for the adjacent sections, the old machine shop

Fig. 2. View of New Section of Erecting Shop, looking nearly West. Boring Mill at the left in background is under Working Test and is Roughing the Faceplate of another Mill. Old Machine Shop Section at the left.

center, and a one-half section used on short work. The side heads are mounted on supplementary, horizontal slides mounted on side rails of the housings. These slides solidly support the side heads when they are extended clear in to the sides of the platen. In this manner the capacity of a large planer is obtained with a comparatively light platen, which feature enables it to be advantageously used on work of a size and weight far less than its normal capacity.

Soon after the building of the erecting and heavy machine shop the increasing demand for heavy machine tools made it imperatively necessary to have more room, as the space between the old machine shop and the erecting shop, was roofed over, and the brick walls between them torn down. This gave one floor nearly 150 feet wide and 234 feet long in the main part. The old machine shop was extended to South Street, making it nearly 349 feet long. Its width is about 37 feet. The

forming one side. The floor in both of the new sections is of heavy plank laid on beams which are bedded in steam ashes. The floor in the machine shop is of brick, being the original floor and still in fair condition. Railroad switches run directly into both sections of the erecting shop, and a switch is laid along the side of the foundry. Crossing these tracks are shop tracks of standard railway gage for short cars on which heavy castings may be delivered from the foundry to the machine shop or erecting shop, by different routes, using either the railway tracks or the shop tracks. Another switch delivers coal directly into the boiler rooms supplying the shop engine.

The superintendent's office is in the drafting room, and just back of the drawing room is the pattern shop. This arrangement brings the two departments in close touch. The location of the superintendent's office is convenient to all

Fig. 3. New section of the Erecting Shop, looking nearly East.

Fig. 4. View of Foundry showing the newer part. Two Traveling Cranes.

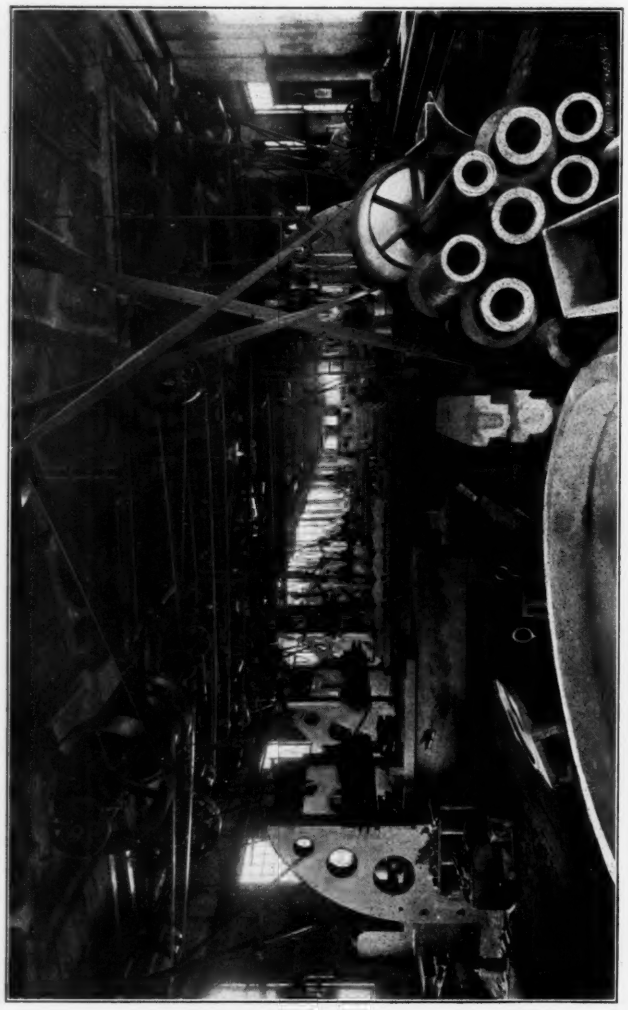

Fig. 5. View in Old Machine Shop Section, looking nearly East. Small Planer Department in Foreground.

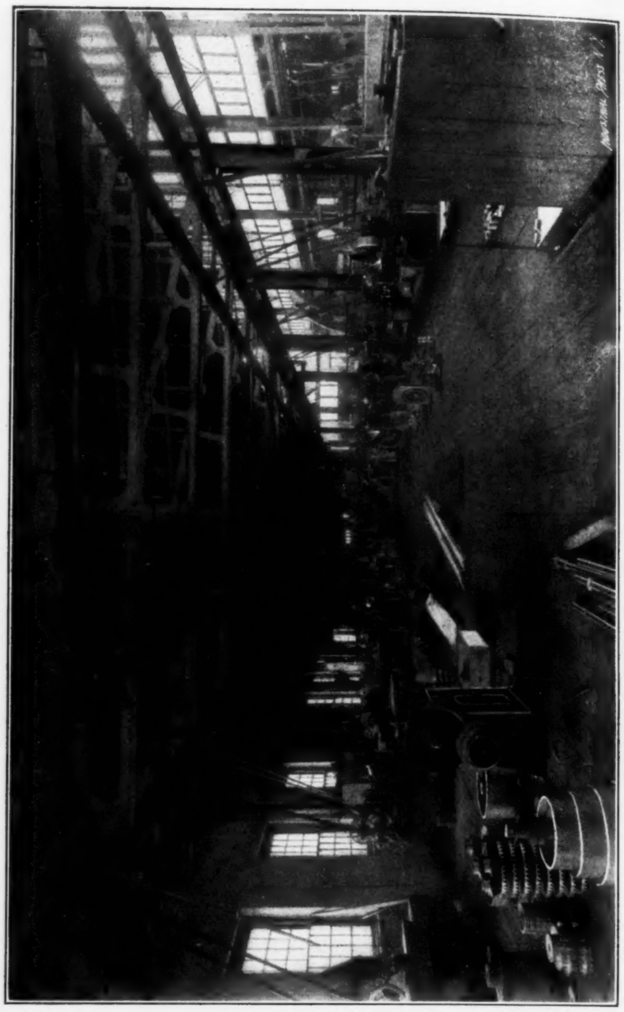

Fig. 6. View of Old Machine Shop from opposite end. The Screw Machines are at this end.

parts of the machine and erecting shops, but is somewhat removed from the foundry. The small blacksmith shop is also close at hand.

In the illustrations, Figs. 5 and 6, which are views of the old machine shop taken from opposite ends, it will be observed that the roof trusses are of a peculiar construction seldom or never seen now. They are made of cast iron, and the same principle of construction, but of much longer span, was employed for the roof trusses of the old part of the foundry. The old part is about one-half the length of the present structure. In the new part of the foundry steel trusses, of course, were used. The length of this building is 224 feet and its width is 98 feet. It is well equipped with large cupolas, traveling cranes and the other accessories of a modern foundry. Besides making all their own castings considerable work is done for other parties.

A large storehouse for patterns stands back of the foundry, and another pattern storehouse is located at the opposite side of the plot near the office. As previously remarked, a railroad switch is laid alongside the foundry so that coal, coke, sand and iron may be brought directly to the door or unloaded into the adjacent storage sheds.

Fig. 7. View of the Erecting and Heavy Machine Shop first built, looking nearly East toward South Street.

THE BETTS WORM-DRIVEN BORING MILL.

An interesting feature of the product of the Betts Machine Co. is the design of their worm-driven boring mill, which they have been manufacturing for the past few years. In this machine—made in 5-foot, 6-foot and 7-foot sizes—the cone pulley is mounted on a shaft carrying a triple-thread, bronze worm engaged with the teeth of a cast-iron worm wheel, which is bolted directly to the under side of the revolving table or faceplate. The worm-gear driving mechanism makes a simple and powerful combination, since a large velocity ratio may be effected with only two members, and efficiently, too, it appears, when the proportions of diameter and pitch are correctly designed. In the 5-foot mill the worm wheel has 72 teeth of 1½ inch pitch, and since the worm engaging it has a triple thread of 4½ inches lead (1½ inch pitch), it follows that the velocity ratio is 24 to 1, that is, the cone pulley must make twenty-four turns to one revolution of the faceplate.

In the first design of the boring mill a worm wheel and worm of the hour-glass or Hindley type was used, but with indifferent success. What advantage this type of worm gear is supposed to possess in the matter of tooth contact was more than offset by lack of accuracy in the tooth spacing of the worm wheel. That is, it appeared to be impossible to get this type of gear made with the accuracy demanded by modern boring mill practice. In the boring of a small hole, when it is necessary to run the table at high speed, and which is the supreme test of accurately cut gearing, every tooth in the worm wheel insisted on being in evidence in the bored hole, it being possible to tell the number of teeth by simply counting the chatter marks. So the Hindley type of worm and worm wheel was discarded in favor of a plain worm and a simple hob-cut worm wheel.

The worm wheel (note details in Fig. 2, next page) is hobbed on a Gould & Eberhardt machine. Great care is bestowed on the cutting of the worm wheel and in chasing the worm, but after all possible care has been taken it is necessary to carefully grind the two together under exactly the same conditions they will be in in use. This is done, of course, by assembling them and grinding in the boring mill for which they are designed. A tooth space of the worm wheel is first marked; also a spot on a thread of the worm. The two are then engaged so that these marks coincide, and the grinding begins. White sea sand mixed with water is the abrasive used, it having been found superior to other combinations. It has also been found that when grinding has once been started, there must be no let-up in pressure, but that the worm must be forced against the teeth with considerable pressure, and followed up as the grinding proceeds. If the attempt is made to grind with the two running together

freely, the invariable result is an inaccurate job which can be corrected only with difficulty. But by forcing the worm during the grinding process the high spots are worn down uniformly, and the tendency seems to be to form all the teeth to same thickness and pitch. This applies, of course, only when the original limits of inaccuracy were narrow. Another effect of the grinding is that the mating members are, to a minute extent, made to imitate the shape of the Hindley worm and worm wheel. During the grinding process the boxes E E', Fig. 3, are held loosely by their bolts. Simple

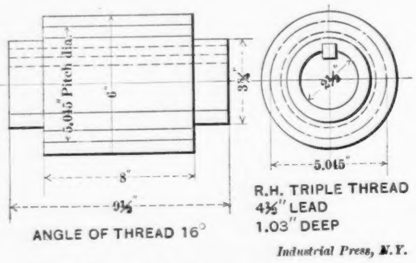

Fig. 1. Details of Worm for Five-foot Mill.

wrought-iron fixtures with setscrews are clamped to the boring mill frame behind the boxes, and the screws are used to force the worm against the worm wheel.

The end thrust of the worm is taken by a ball-bearing containing 14 balls ⅞ inch diameter, in the case of a 5-foot mill. Regarding the use of a ball bearing for duty like this there seems to be no trouble when the balls are proportioned for the work they have to do. Most of the trouble encountered when the ball bearing has been used for heavy work, is due either to its not being proportioned to the pressure, or to the speed having been too great. In this case the highest speed is about 600 revolutions per minute, which is the speed necessary to give the periphery of a 4-inch hole a velocity of 25 feet per minute. The worm and worm wheel run in a bath of oil, insuring perfect lubrication at the comparatively low speed at which the worm wheel operates. In the 5-foot mill the worm is 8 inches long, 6 inches outside diameter, 5.045 inches pitch diameter, depth of thread 1.03 inches. As already stated it is triple thread, 1½ inch pitch and 4½ inches lead. The angle of thread, with a line perpendicular to its axis, at the pitch diameter is 16 degrees. Fig. 4 shows the faceplate removed and the worm and ball bearing exposed to view.

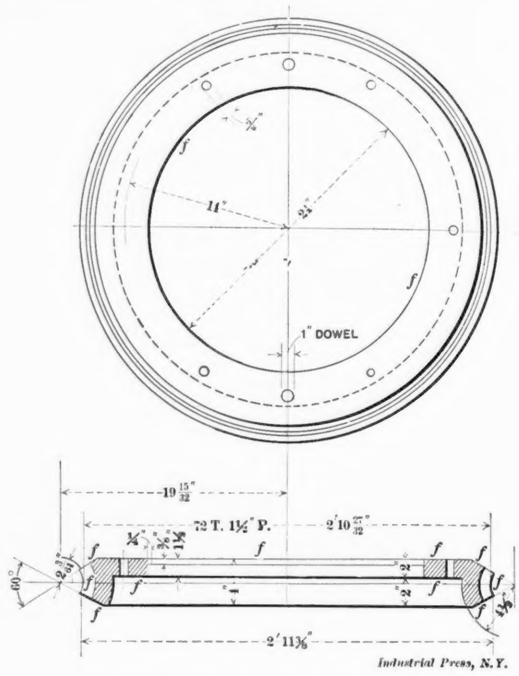

Fig. 2. Details of Worm-wheel for Five-foot Mill.

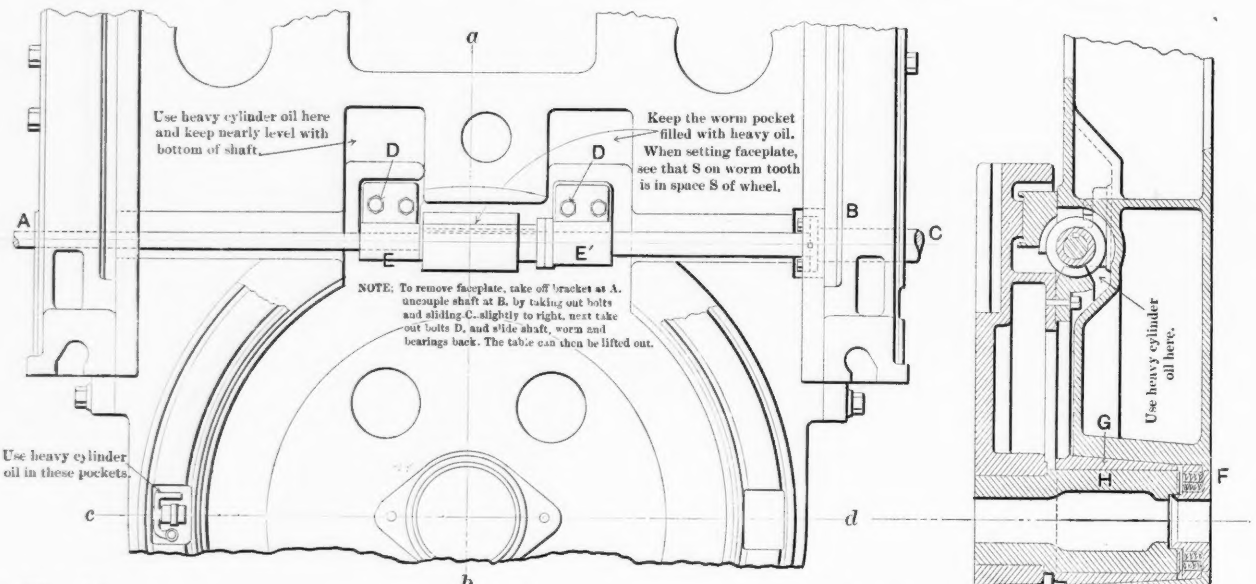

Fig. 3. Instruction Sheet sent out with Worm-driven Boring Mill, showing Construction and giving Directions as to Care, etc.

Another interesting feature of this design of boring mill is the step bearing, and the manner of relieving the load on the outside ring bearing. The common practice in boring

mill construction, as we all know, is to provide screw connection in the front of the base by which the operator can take part of the load off the ring bearing and place it on the pivot or step bearing, when running at high speeds. Like all features of adjustment in machine construction, this one is likely to be abused. If the table is lifted too high, which is likely to be the case unless the operator is more than ordinarily careful, there will likely be a lack of concentricity between the turned periphery of, say, a pulley and the hole bored in the hub. In the Betts mill no adjustment is provided for the operator to manipulate. The load on the outer bearing ring is relieved automatically and at all speeds. A circular cast-iron disk fits in the bottom of the spindle hole. This is drilled with a number of $\frac{7}{8}$-inch holes, say, 24. In these holes are placed a certain number of coiled springs, the number being determined by experiment on each mill. On top of the springs is a bronze plate upon which rests the spindle *H*. Fig. 3, of the table. When the mill is assembled, the disk *F* is partly filled with springs, say 22 are put in. The table is lowered with strips of thin paper placed on the outer bearing ring. If, when the table is down, the strips of paper are found loose, some of the springs are removed—say 2. This leaves 20, and then the table is replaced. If then the

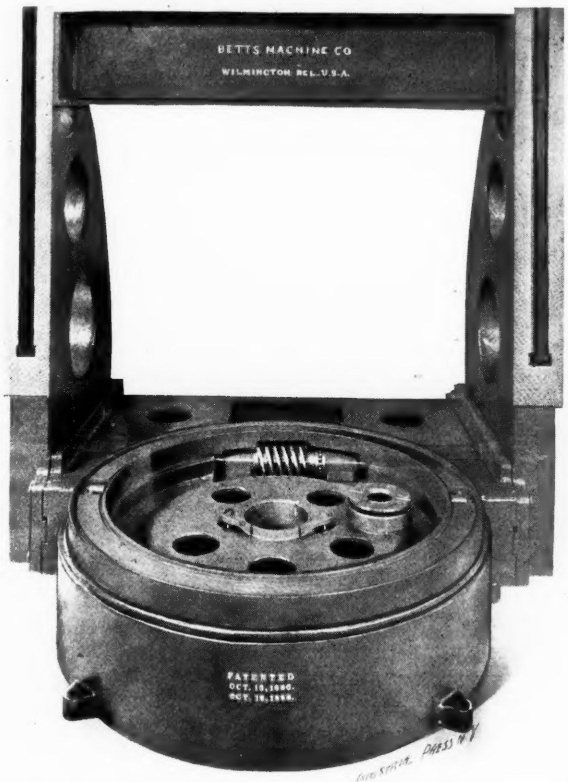

Fig. 4. View of Boring Mill with Faceplate removed, showing Worm, Ball Thrust Bearing and Step Bearing.

strips of paper are found to be pinched, it is fair to presume that the weight of the table is approximately balanced by the springs. The condition of approximate balance having been determined, the table is again removed and one-fourth of the number of springs taken out, leaving in this case 15 springs in place. In this way it is calculated that 75 per cent. of the weight of the table is balanced on the step bearing. Of course the weight of the work on the table reduces the proportion of the load borne by the step, but as it is usually only comparatively light work that is run at high speeds, this objection is not considered serious. The step bearing is also shown in Fig. 4, setting beside the spindle bushing.

The cut, Fig. 3, used to show the principle of construction, was made from an instruction blueprint regularly sent out with all worm-driven boring mills. The plain directions for the care and adjustment of the mill are reproduced. While there is nothing new in sending out instruction sheets like these, in our opinion many machine tool builders could very profitably follow and extend the practice. Anything that will help a machine to be understood and cared for is to the mutual profit of all concerned.

THE DIFFERENTIATION OF ENGINEERING.

The best definition of civil engineering is probably that which was given seventy-five years ago by Thomas Tredgold, namely: "Civil engineering is the art of directing the great sources of power in nature for the use and convenience of man." At the time this was written, however, there were but two recognized branches of engineering, one designated as civil engineering, and the other as military engineering, the former including all those branches not directly connected with military operations. But the remarkable series of mechanical inventions which distinguished the last third of the eighteenth century—the spinning jenny by Hargreaves, the spinning frame by Arkwright, the mule by Crompton, the power loom by Cartwright, the steam engine by Watt, the puddling process by Cort, and others—followed in the first third of the past century by the development of the steam locomotive by Stephenson, the steamboat by Fulton, and by further great improvements in the manufacture of iron and steel, soon led to the differentiation of civil engineering into several branches. The first branch to leave the parent stem was mechanical engineering, followed by metallurgical and mining engineering as the developments in the mining and reduction of metals progressed; and toward the middle and end of the last century the tremendous advance in all branches of applied science speedily differentiated engineers into the classes named, as well as into others. For instance, within the last quarter of a century the development of the electric motor and other great discoveries in electrical science have led to the development of electrical engineering as a distinct profession, while the advances in sanitary science and the discoveries with reference to the nature, causes and prevention of disease have resulted in the development of sanitary engineering as a branch of civil engineering quite extensive enough to constitute a profession by itself. But notwithstanding the divergence of all these branches from the parent stem of civil engineering, even what is left to be included under this title remains undoubtedly the widest in scope of all the engineering professions, and in practising it a man must become a specialist in some one branch. It comprises the construction of railroads, of roads, of canals, of street and interurban railways, the improvement of rivers and harbors, the construction of lighthouses and other works necessary for carrying on trade and commerce; it includes structural engineering, or the construction of bridges, aqueducts, foundations, steel frames for buildings, etc.; it treats of hydraulic engineering, including the development of water powers, and the construction of dams and power plants up to the point at which the mechanical engineer is called upon to supply the motors; it deals with surveying, which is necessary in the laying out of works of all kinds, but constitutes also a branch by itself known as land surveying, which, when extended to the survey of very large areas in which the curvature of the earth must be taken into account, leads to the intricate problems of geodesy, or the measurement of the earth, and touches upon the field of terrestrial physics; and it further includes a great variety of problems due to the congregating of persons in cities—undoubtedly the most striking sociological development of the last century—including works of water supply, sewerage, the drainage of buildings and lands, the disposal of wastes, and the construction and maintenance of streets and pavements. This last group of problems, involving the health of communities, although now the special field of the sanitary engineer, is more generally considered as a branch of civil engineering. Broadly speaking, it may be said that civil engineering deals with structures, or works at rest; while mechanical engineering deals with machines and motors, or works which are in motion. It will be seen, however, that the execution of civil engineering works requires at many points the collaboration of the mechanical or the electrical engineer, and that it also brings the practitioner into close contact with economic and sociological problems.—*Prof. Geo. F. Swain in the N. Y. Tribune.*

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Machine shop profits to-day are made up out of time that used to be wasted by the old methods.

ACCURATE MACHINE DESCRIPTION.

A NOVEL METHOD OF MAKING NOTES OF MACHINE DIMENSIONS.

CHARLES H. FITCH.

In order to solve a problem we must know its elements. If the solution is graphical, these elements are measures of lines or dimensions. If it be arithmetical the elements are numbers. If analytical or algebraical the elements are quantities designated by letters to which numeral values may be assigned, or which may have definite relations to each other whether values are assigned to them or not. It is usually more convenient to solve problems graphically than analytically, but the analytical solution may be more exact, and the study of the problem by analysis sometimes leads to the discovery of new and useful relations. A well qualified mechanical engineer and mathematician is able to use analytical methods, although where equations become involved and complicated most practical men would beg off from the time, mental labor and difficulty involved by this treatment.

I hold, however, that all methods have their uses, and that there is in particular a useful unoccupied field for such accurate text descriptions as will enable a draftsman to sit down with them and develop therefrom all the drawings necessary to make patterns and do the machine work—in fact, to build the machine from the text.

As it is now, we all know that machine descriptions are very loose and incomplete. The text gives us an idea of the general nature of the machine by appealing to our familiarity with similar constructions and mechanical elements. This is usually assisted by a picture of the machine in perspective, and perhaps by sectional drawings on too small a scale for accurate reproduction by taking off measurements with dividers.

This may suffice very well for general public information in cases where it is not desired to tell too much or to make it too easy to copy the machine. To do this the machine must be re-designed. The description and cuts are, in fact, a language designed "to conceal thought," although it would be more accurate in this case to say that the language was partly to conceal and partly to reveal the thought embodied in the machine.

We have to offer in this article a kind of description which will suffice for the location of all the center lines and axes of motion and working surfaces of a machine, and take for illustration the slotting and drilling machine shown in cuts Fig. 1 and Fig. 2.

The scheme of description is as follows:

All points, lines and regular definable surfaces in space can be referred to three planes and will then be completely determined. In some cases it may be convenient to choose parallel planes for convenience of reference, but practically we have three planes in any case. The planes chosen have traces or projections shown by broken lines on Figs. 1 and 2. Directions with reference to the several planes are indicated by letters.

From the horizontal plane, *ab* = above, below.

From the face vertical plane, *fn* = far, near.

From the cross vertical plane, *lr* = left, right.

These planes are as assumed in Fig. 1.

Now if we start our description with the driving shaft of the platen power feed, its direction is *lr*, left to right. Its center is 5" *a*, that is 5" *above* horizontal plane; and 4¾" *f*, that is, 4¾" *far* or beyond (not near, or this side of) the face vertical plane. The location is not shown in Fig. 2, being behind plate of frame, the axis being No. (1) gearing with No. (19).

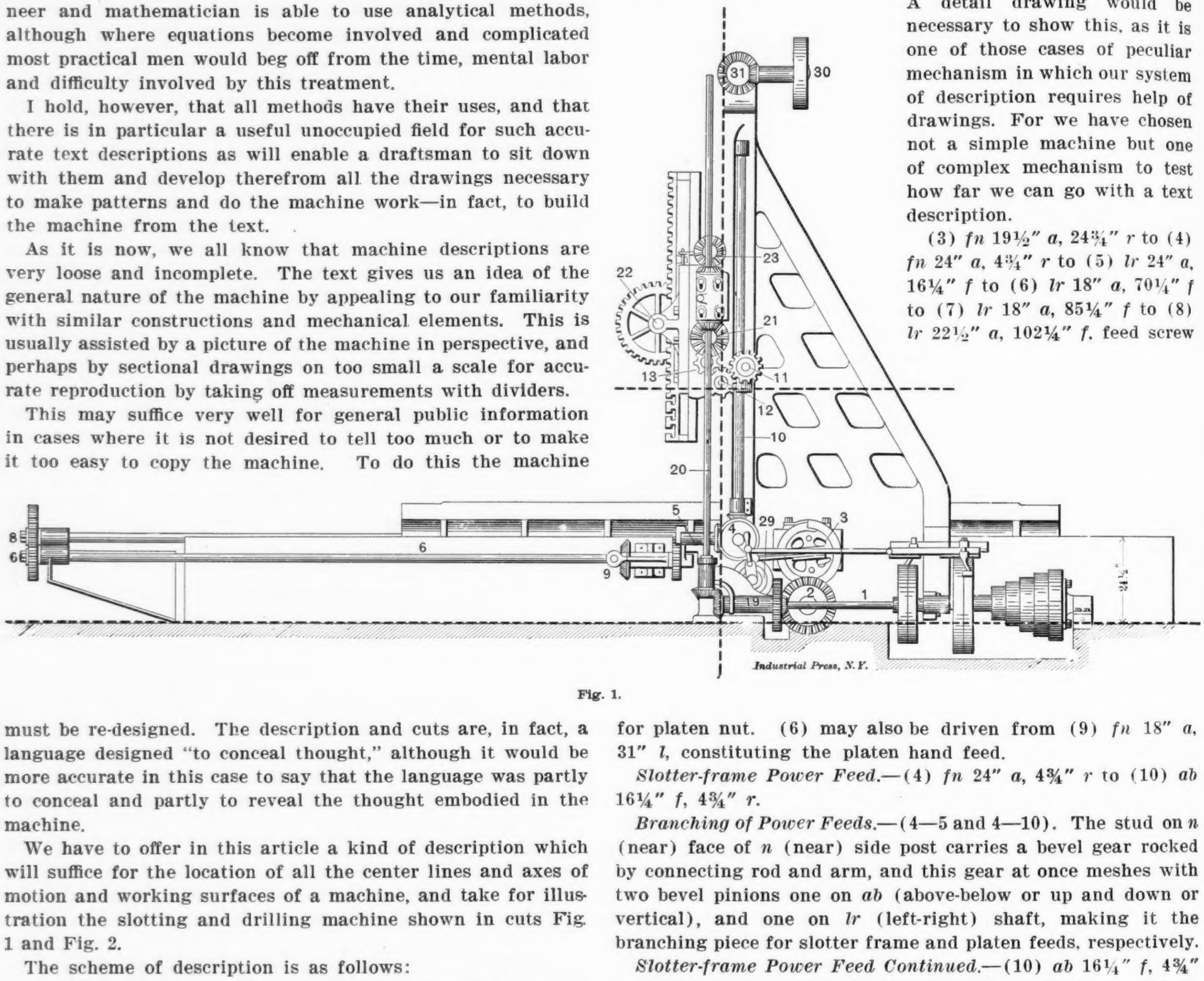


Fig. 1.

Designating axes of motion by numbers in parenthesis, the above description may be condensed and proceeded with as follows:

Platen power feed. (1) *lr* 5" *a*, 4¾" *f*, driving shaft to (2) *fn* (far near direction) 5" *a*, 24" *r* (24" to the right) to (3) *fn* 19½" *a*, 24¾" *r*.

Note on (2-3); feed escapement. The intermittent feeds are given by a peculiar escapement movement which, in conjunction with ratchet wheels in the dependent trains, regulates the feeds. A friction pinion grooved about its girth meshes with a friction wheel having a segmental half-around grooved rim, either end of the grooves having a partial extension in a toothed pawl hung within the wheel, so that while connection is broken after a half turn either way, and the feed motion is positively stopped by lugs, upon reversal of motion of the pinion the wheel re-engages by means of one of the pawls. A detail drawing would be necessary to show this, as it is one of those cases of peculiar mechanism in which our system of description requires help of drawings. For we have chosen not a simple machine but one of complex mechanism to test how far we can go with a text description.

(3) *fn* 19½" *a*, 24¾" *r* to (4) *fn* 24" *a*, 4¾" *r* to (5) *lr* 24" *a*, 16¼" *f* to (6) *lr* 18" *a*, 70¼" *f* to (7) *lr* 18" *a*, 85¼" *f* to (8) *lr* 22½" *a*, 102¼" *f*, feed screw for platen nut. (6) may also be driven from (9) *fn* 18" *a*, 31" *l*, constituting the platen hand feed.

Slotter-frame Power Feed.—(4) *fn* 24" *a*, 4¾" *r* to (10) *ab* 16¼" *f*, 4¾" *r*.

Branching of Power Feeds.—(4—5 and 4—10). The stud on *n* (near) face of *n* (near) side post carries a bevel gear rocked by connecting rod and arm, and this gear at once meshes with two bevel pinions one on *ab* (above-below or up and down or vertical), and one on *lr* (left-right) shaft, making it the branching piece for slotter frame and platen feeds, respectively.

Slotter-frame Power Feed Continued.—(10) *ab* 16¼" *f*, 4¾" *r* to (11) *fn* 7" *a*, 4½" *r* to (12) *fn* 2½" *a* 2, 1½" *l* to (13) *fn* 8¾" *a* 2, 4 3-16" *l*, feed screw for slotter-frame nut. The *a*2 merely indicates that we have transferred our horizontal reference plane to an upper movable plane.

Slotter-frame Hand-feed.—(14) *lr* 26" *a*, 192¾" *f* to (15) *ab* 2¾" *r*, 192¾" *f* to (16) *fn* 2¾" *r*, 8¾" *a*2, to (13) *fn* 4 3-16" *l*, 8¾" *a*2.

Drill Frame Hand Traverse.—(17) *lr* 6 7-16" *a*2, 9½" *n*2 to (18) *lr* 11 7-16" *a*2, 9½" *n*2, axle of traverse wheel meshing with thread of screw (13). The use of *n*2 obviously indicates transition to another *fn* (far near) vertical reference plane, parallel with the first, and movable.

Slotter Tool Train.—(1) *lr* 5" *a*, 4¾" *f* to (19) *lr* 5" *a*, 6" *n*, to (20) *ab* 4½" *l*, 6" *n* to (21) *fn* 4½" *l*, 14¼" *a*2, *to* (22) *fn* 18" 55 *l*, 19½" *a*2.

Drill Tool Train.—(20) *ab* 4½" *l*, 6" *n* to (23) *fn* 4½" *l*, 40⅜" *a*2, to (24) *ab* 4½" *l*, 11" *f*2 to (25) *ab* 11¼" *l*, 0" *f*2. Note on tool train engagements (20 to 21) and (20 to 23): A single train of mechanism serves to operate either drill or

slotting tool with the following disengaging device. The upper part of *ab* (or vertical) power shaft for the tool motions is carried by a bearing bolted upon *n* (near) end of cross-slide with bolt holes elongated *ab* (or vertically) so that the bearing may be slipped and set up or down, carrying with it a bushing having a bevel pinion below and a miter above the bearing, either one of which may be thus disengaged, while the other is thrown into gear with its train.

The Slotting Bar (22 and following). The rack of slotting bar has a 6" face *fn*, and extends *l*-ward (or to the left) from a 12" *fn* by 2½" *lr* slide bar retained on either side by gibs, while take-up for wear is provided by three long *ab* keys two on *l* side, either side of rack and one on *n* side of bar, which keys are set by means of stud bolts in the slotter frame, with jamb nuts.

Drill Feed Train.—(23) *fn*, 4½" *l*, 40⅜" *a2* to (26) *fn* 8¾" *l*, 47⅞" *a2* to (27) *fn* 14 15-16" *l*, 33" *a2*, to (28) *ab* 19 1-16" *l*, 13" *f* to (25) *ab* 11¼" *l* to 0" *f2*. Drill feed train (23 to 26) spurs are geared 50 to 58 teeth, (26 to 27) cone pulley of 4 steps 12" diameter to 4" diameter, faces 1⅝", belting to cone pulley 6½" diameter to 14½" diameter. (27 to 28), worm gearing with worm wheel (28 to 25), spurs geared in ratio 3 to 5, the latter keyed on nut of feed screw extension of drill spindle. The screw is right hand, square thread, ½" pitch, 47¼" long, and with thrust bearings above and below. Where it joins drill spindle there is keyed upon it a cross-bar whose *fn* wings guide in slots of *ab* pillars of the drill frame.

Belt Shifting Train.—(1) *lr*, 5" *a*, 4¾" *f* to (29) *fn* 12" *a*, 9¼" *r*.

Cross Slide (ab) Traverse.—(30) *lr* 158 *a*, 12" *f* to (31) *fn* 158" *a*, 6" *r* to (32) *ab* 27½" *f*, 6" *r* and (33) *ab* 174½" *f*, 6" *r*.

This sufficiently illustrates the plan of a universal system of description of machinery trains and elements.

The first suggestion is that it may add new terrors to technical reading. That may be so, but if we take up a magazine devoted to textile design or ladies' embroidery we will encounter long descriptions for making patterns and stitch work designs which are essential to communicate the necessary information and which are very useful although they may have to be read needle in hand, and be no more suited to thrill the soul than are the genealogical records in the books of Moses.

This plan is, I think, worth putting on record in the technical engineering press, because it has utility. The foregoing description looks a little complex, but it is of a complex machine with many trains, the full details of which would require a large drawer full of drawings. I have found it useful in simpler cases in several ways.

First, as a time and labor saver. I can borrow a set of drawings and in a very short time can take off all the details necessary for their entire reproduction.

Second, as an inconspicuous record. These notes take hardly any space, and are a sort of shorthand which the casual reader cannot make out. They are private to that extent.

Third, as a check. A draftsman can use these dimensions to check his drawings.

Fourth, for clearness of ideas. No one can analyze a machine in this way without knowing it better, and remembering clearly points that would otherwise be left in doubt or obscure.

There is still another useful purpose to which this method can be put. In comparing designs and designing in series, it helps to determine what is best, what parts can be worked to interchange, or used on several sizes or modified designs of a machine.

THE REVOLUTION EFFECTED BY FARM MACHINERY.

Farm machinery may some time do work for us that will be worth $1,000,000,000 a year. Theoretically it is already saving us nearly three-fourths that sum; for as far back as 1899, if all the crops to which machinery is adapted could have been planted and gathered by hand, they would have cost nearly $700,000,000 more than if they had all been planted and gathered by machinery. It has not only added so much to our wealth, but it has made us the foremost exporting nation, and it is changing the character of the farmer by freeing him from monotonous hand-toil. More than that, it is fast changing the immemorial conception of agricultural and the pastoral and idyllic associations that have gathered about it since the time of Abraham. Wealth, industry, commerce, the character of men and even their sentiment are all affected by it.

Yet so sudden have been these changes that we have yet hardly caught their meaning. The cradle-scythe is only a little more than a century old, and the cast-iron plow was first used even later than the cradle-scythe. In other words, a century ago agricultural machinery was almost as primitive as it was a thousand years ago. Now we have steam plows, combined harvesters and threshers and auto-mowers. They have come into use so recently that only a small part of the population have ever seen them at work. Yet they are changing our life in all its wide reaches—from commerce to poetry.—*World's Work.*

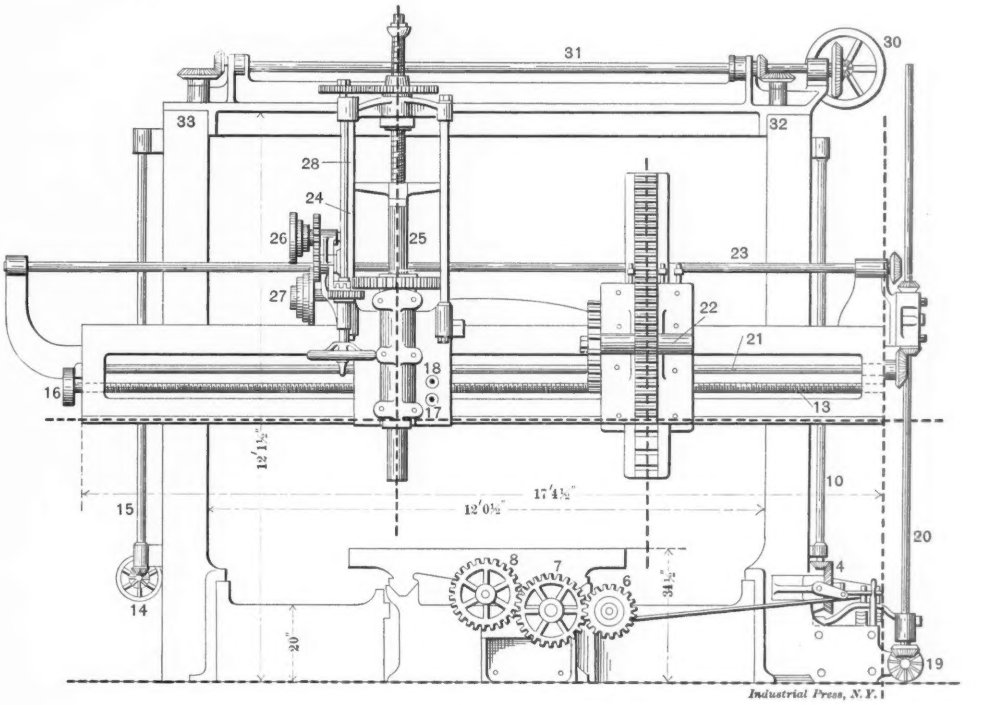


Fig. 2.

* * *

A dozen miles up the Tyne Valley is the village of Wylam, where George Stephenson was born, in 1781. The old home is still there—a very plain, peak-roofed, stone cottage, now tenanted by a peasant family. On the ends of the cottage there are no windows, and there are but five on the front. In the eighteenth century, in England, windows were a luxury, for the householder had to pay a tax on them. This window tax was the outgrowth of the hearth tax. In earlier days the collector came around to count the number of fireplaces, that the householder might be taxed on them, but the English spirit—"every man's house his castle"—was opposed to this invasion of the privacy of the home, and the window tax was substituted as a tax that might be assessed from outdoors. Just in front of the Stephenson cottage runs one of the railways made possible by the genius of the inventor.—*Four Track News.*

* * *

Prof. Forrest R. Jones, who has contributed to our columns occasionally, is to leave Worcester Polytechnic Institute to become Professor of Machine Design at Sibley College, Cornell University.

SPIRAL GEARS.

DEVELOPMENT OF THEORY AND RULES FOR THEIR CALCULATION.

C. E. COOLIDGE.

The fact that the design of a pair of spiral gears involves so many possibilities and probabilities before the "eternal fitness of things" results, has stimulated a great many interested in the development of a pair of spiral gears to evolve methods which would require a minimum amount of labor. Graphical methods are most easily followed and understood by many, but a rigid and expedient treatment can only be obtained by the use of true and convenient equations which express the kinematic and kinetic relations of known properties of the gears.

The introduction of the terms sine, cosine, and tangent into the equations should not be held in abject terror by those who have thus committed themselves through the columns of current periodicals. The trigonometrical terms sine, cosine, and tangent of an angle express the ratio of two particular sides of a triangle with reference to the particular angle used, and with the multitudinous number of available books which contain the values of the ratios, common everyday arithmetic is substituted for the science of trigonometry as such.

The fundamental kinematic features of screw gearing, and in fact of all gearing, are nothing but special cases of the skew gear which is the general case. In other words, the skew gear with its hyperboloidal pitch surface is the mother gear of all.

A brief presentation of that particular feature might aid some in plucking a "brand from the burning" and I take the liberty of indicating a proof by the analysis of a pair of skew gears as follows: In the two views in Fig. 1, let *A-A*, *B-B*, and *l-l* represent the axes and line of contact respectively of a pair of skew and screw gears in contact whose axes are parallel to the plane of the paper. Also let

$V =$ component linear velocity of point P common to both gears and perpendicular to line of contact *l-l*,

$V' =$ component linear velocity of point P in line of contact taken perpendicular to axis *A-A*,

$V'' =$ component linear velocity of point P in line of contact taken perpendicular to axis *B-B*,

$\alpha =$ angle between lines $V'P$ and PV,

$\beta =$ angle between lines $V''P$ and PV,

$R =$ radius of gear whose axis is *A-A*,

$R' =$ radius of gear whose axis is *B-B*,

$R\,P\,M =$ rev. per min. of gear whose axis is *A-A*,

$R'\,P'\,M' =$ rev. per min. of gear whose axis is *B-B*.

The angular velocities of the two rolling hyperboloids are directly proportional to their R. P. M's and since the angular velocity equals the linear velocity divided by the radius of the rotating body we have

$$\frac{R\,P\,M}{R'\,P'\,M'} = \frac{\dfrac{V'}{R}}{\dfrac{V''}{R'}} = \frac{V'}{V''} \times \frac{R'}{R}, \qquad (1)$$

$$\frac{V'}{V''} = \frac{\dfrac{V}{V''}}{\dfrac{V}{V'}} = \frac{\cos\beta}{\cos\alpha} \qquad (2)$$

$$\frac{R}{R'} = \frac{R'\,P'\,M'}{R\,P\,M} \times \frac{\cos\beta}{\cos\alpha} \qquad (3)$$

From (3) it is evident that the radii of the two gears are inversely proportional to the rotations about their axes if in Fig. 1 the angles made by the line of contact with the axes are equal, which is often of advantage in laying out screw gears.

The special cases of the skew gear as found in the more common gears are as follows: When the throat of the hyperboloidal surfaces contracts to a point, a double nappe cone with intersecting axes or the pitch surfaces of bevel gears results, with a zero velocity at P. When the hyperboloids are infinitely long, cylinders with parallel axes or the pitch surfaces of spur gears and twisted gears result with angles α and β equal to zero and the line of contact *l-l* making zero and equal angles respectively with the axes. When comparatively narrow lengths of the hyperboloidal surfaces, which are close approximations to cylinders, are used and the teeth are twisted into regular helices, the line *l-l* becomes a tangent to the helices at the point P and screw gears known under the more general term of spiral gears result.

Worm gears come under this head as a species of screw gear.

The designing draftsman of a pair of spiral gears must furnish the following data for use in the shop:

1. Outside diameters of the gears.
2. Pitch and number of cutter used.
3. Number of teeth cut.

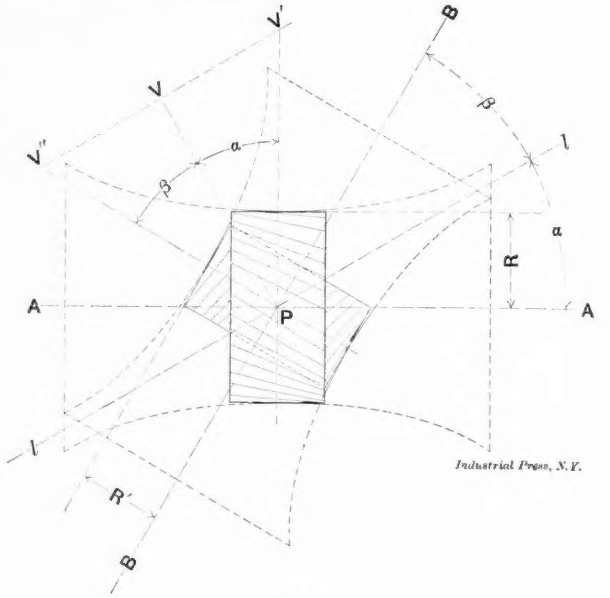


Fig. 1

4. Lead of spiral.
5. Angle of spiral with axis.

For working out the data for the shop the following formulæ with their derivation are adequate and convenient. Using the notation above and adding

$d =$ sum of pitch radii of gears and shortest distance between axes,

$N =$ number of teeth on gear whose axis is *A-A*,

$N' =$ number of teeth on gear whose axis is *B-B*,

$n =$ number of teeth on osculating circle of gear whose axis is *A-A*,

$n' =$ number of teeth on osculating circle of gear whose axis is *B-B*,

$D =$ diametral pitch,

$a =$ lead of spiral of gear whose axis is *A-A*,

$a' =$ lead of spiral of gear whose axis is *B-B*,

we have

$$\frac{N}{N'} = \frac{R\,P'\,M'}{R\,P\,M} \qquad (4)$$

$$\frac{R}{R'} = \frac{R'\,P'\,M'}{R\,P\,M} \times \frac{\cos\beta}{\cos\alpha}, \qquad (5)$$

$$n = \frac{N}{\cos^3\alpha}, \qquad (6)$$

$$n' = \frac{N'}{\cos^3\beta}, \qquad (7)$$

$$a = 2\,\pi\,R\,\text{tang}\,(90^\circ - \alpha), \qquad (8)$$

$$a' = 2\,\pi\,R'\,\text{tang}\,(90^\circ - \beta), \qquad (9)$$

$$\frac{2\,d\,D}{N'} = \frac{1}{\cos\beta} + \frac{R'\,P'\,M'}{R\,P\,M} \times \frac{1}{\cos\alpha}. \qquad (10)$$

(4) is self-evident, being the common property of all gearing. (5) has been derived for skew gears and answers for spiral gears which are a special case of skew gears as indicated above. In equation (6) the derivation is as follows: In Fig.

2 is shown one of the pair of gears shown in Fig. 1, whose axis is A-A. Using the notation above and adding

p = normal pitch,
c = circumferential pitch,
s = semi-major axis,
r = radius of osculating circle.

If a cutting plane be taken perpendicular to the plane of the paper and to the tangent line l-l at the point P an ellipse will be cut from the cylinders whose true configuration is shown revolved into the plane of the paper. The radius of the osculating circle (a circle touching the greatest number of points) to the ellipse at the end of the minor axis is derived most easily from Calculus and its value is equal to the square of the semi-major axis divided by the semi-minor axis or from Fig. 2,

$$r = \frac{s^2}{R}, \tag{11}$$

also from Fig. 2, $s = \dfrac{R}{\cos\alpha}$. (12)

Substituting s in (11), $r = \dfrac{R}{\cos^2\alpha}$. (13)

Multiplying the diameter of a circle by the diametral pitch gives the number of teeth on the circle or the number of teeth on the osculating circle just found,

$$n = 2\,r\,D = \frac{2\,R\,D}{\cos^2\alpha} \tag{14}$$

$$\text{Since } D = \frac{\pi}{p}, \tag{15}$$

and from Fig. 2, $p = c\cos\alpha$. (16)

Substituting p in (15), $D = \dfrac{\pi}{c\cos\alpha}$. (17)

Substituting D in (14), $n = \dfrac{\dfrac{2\,\pi\,R}{c}}{\cos^3\alpha}$. (18)

Since $\dfrac{2\,\pi\,R}{c}$ = number of teeth on gear, $n = \dfrac{N}{\cos^3\alpha}$.

Equation (7) is derived similarly to (6). Equation (8) is derived as follows: In Fig. 3 let one of the pair of spiral gears shown in Fig. 1 with axis A-A be sufficiently extended to complete one turn of the helix about the pitch cylinder. In

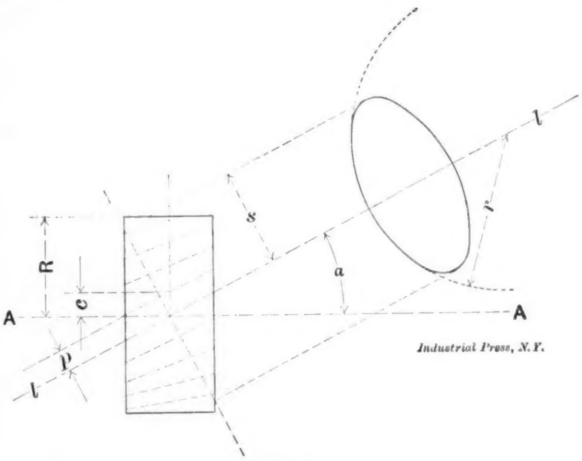


Fig. 2.

the lower view of Fig. 3 the development of the cylinder and the helix on its surface readily shows that $a = 2\,\pi\,R$ tang $(90° - \alpha)$.

Equation (9) is derived similarly to (8).

Equation (10) is derived as follows: With notation as above,

$$\frac{2\,\pi\,R}{2\,\pi\,R'} = \frac{c \times N}{c' \times N'} \tag{19}$$

which is an equation whose members are identities.

Adding numerators and denominators of each member of (19).

$$2\,\pi\,(R + R') = c \times N + c' \times N'. \tag{20}$$

From Fig. 1 and Fig. 2 it is seen that

$$c = \frac{p}{\cos\alpha} \tag{21}$$

and

$$c' = \frac{p}{\cos\beta}, \tag{22}$$

also $p = \dfrac{\pi}{D}$. (23)

Substituting p in (21) and (22),

$$c = \frac{\pi}{D\cos\alpha}, \tag{24}$$

and

$$c' = \frac{\pi}{D\cos\beta} \tag{25}$$

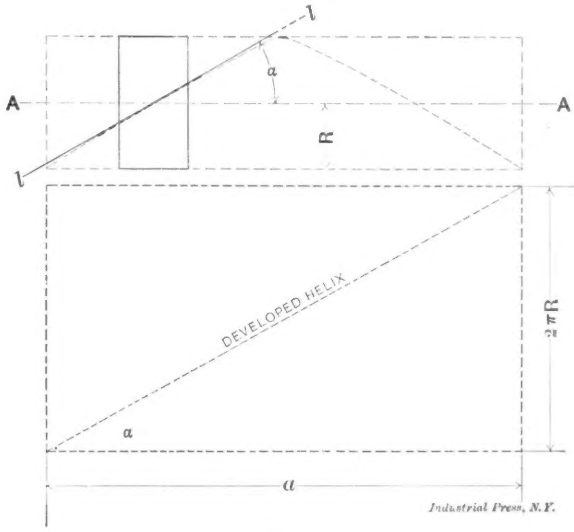


Fig. 3.

Substituting c and c' in (20),

$$2\,\pi\,(R + R') = \frac{\pi\,N}{D\cos\alpha} + \frac{\pi\,N'}{D\cos\beta} \tag{26}$$

Multiplying through by D, dividing by N' and π, and noting $R + R' = d$,

$$\frac{2\,D\,d}{N'} = \frac{1}{\cos\beta} + \frac{N}{N'} \times \frac{1}{\cos\alpha}. \tag{27}$$

Substituting $\dfrac{R'\,P'\,M'}{R\,P\,M} = \dfrac{N}{N'}$ in (27),

$$\frac{2\,D\,d}{N'} = \frac{1}{\cos\beta} + \frac{R'\,P'\,M'}{R\,P\,M} \times \frac{1}{\cos\alpha}.$$

If the equipment of the shop was complete and there were no objectionable kinematic considerations, the simplest and perhaps the most efficient pair of gears would obtain when the tangent to the helices makes equal angles with the axes. However, the following considerations are important and condition the final data which is sent to the shop:

1. If the number of R. P. M.'s of each shaft is fixed, the ratio of the number of teeth is also fixed and there can be no fractional tooth.
2. A stock cutter must be used which approximates size of tooth designed.
3. Occasionally the gear shafts are fixed in position and consequently the distance between them is fixed.
4. The leads of the two spirals must be such as can be cut on a universal milling machine or some special gear cutter.

It is usually the case that all four conditions cannot be satisfied. Those in 1 and 2 are usually fixed. Those in 3 can often be changed in the early stages of a new design by changing the angle of shafts and the distance between them. Those in 4 can usually be met by making new gears for the machine which is used in cutting the spirals and it may be that it is quite possible to change the angle of teeth and distance between shafts so as to cut at least the lead of one of the gears with the regular change gears on the machine.

To illustrate the procedure for applying the formulæ used in determining the necessary data for the shop, a specific problem will be taken. Suppose there are two non-intersecting shafts making an angle of 60 deg. with each other when their axes are parallel with the plane of the paper; the driving shaft makes 70 R. P. M. and the driven shaft 120 R. P. M.; the shortest distance between axes will be taken tentatively as 12 inches; and a 3-pitch cutter will be used.

We will assume that the angle of the teeth is the same for both gears, or 30 deg. Then substituting in formula (10),

$$\frac{2 \times 3 \times 12''}{N'} = \frac{1}{\cos 30^\circ} + \frac{120}{70} \times \frac{1}{\cos 30^\circ} = 3.134''$$

$N = \dfrac{72}{3.134''} = 22 +$ which indicates that the teeth on the driven gear should be somewhere in the vicinity of 22. It is at once seen that

$$\frac{4 \times 12}{4 \times 7} = \frac{48}{28} \text{ and } \frac{3 \times 12}{3 \times 7} = \frac{36}{21}$$

both of which can be used. Since $N' = 21$ in the last equation is nearer to 22 we will use it. Keeping the angle as before and substituting again in (10) and solving we have

$$d = \frac{3.134 \times 21}{6} = 10.969''$$

which is the required distance between shafts.

Since the pitch radius of one gear is 10.969 minus the pitch radius of the other, by substituting 10.969—R for R' in (5) and solving we have

$$R = \frac{12 \times .866\ (10.969'' - R)}{7 \times .866} = 6.928''$$

and

$$R' = 10.969'' - 6.928'' = 4.041''.$$

The leads of the spirals of the gears are found in (8) and (9) respectively.

$a = 2 \times 3.1416 \times 6.928''$ (tang $60^\circ = 1.732$) $= 75.393''$.

$a' = 2 \times 3.1416 \times 4.041''$ (tang $60^\circ = 1.732$) $= 43.983''$.

If the spirals are cut on a Brown & Sharpe universal milling machine, we find that gears 100, 40, 72, 24 on worm, 1st on stud, 2d on stud, and on screw respectively will cut a spiral with a lead of 75 inches, and gears 100, 40, 56, 72 on worm, 1st on stud, 2d on stud, and on screw respectively will cut a spiral with a lead of 43.75 inches. These two results are unusually close for a chance pair of gears. If we consider the inaccuracies and imperfections which result in the setting of the shafts, in the use of the unsuitable stock cutter, and in the setting of the cutter tangent to the helix, the probabilities are that the gears are practically all right without any change.

The outside diameters of driver and driven are:

$2 \times 6.928'' + \frac{2}{3}'' = 14.522''$ and

$2 \times 4.041'' + \frac{2}{3}'' = 8.748''$ respectively.

The number of teeth in driver is from (6)

$$n = \frac{36}{\cos^3 30^\circ = .649} = 55 +$$

and a No. 2 cutter is to be specified. (The value of the cosine and its cube should be taken directly from tables found in hand books.)

The number of teeth in driven is from (7)

$$n' = \frac{21}{\cos^3 30^\circ = .649} = 32 +$$

and a No. 4 cutter is to be specified.

Occasionally the condition arises where there is a certain fixed distance between shafts as would be the case if a pair of spiral gears replaced some previous driving mechanism in a machine whose shafts could not be changed without great expense. Suppose in the problem above everything was as given except that the distance between shafts must be exactly 12 inches. Our procedure then would be to try equal angles between tangent line and axes and substitute the rest of data in (10) as before. We found above that equal angles gave us fractional teeth which indicates that we will have to change the angles and use the next lower number of teeth that will give the proper ratio which is 36 and 21. (If we had used in this case 48 and 36 we would not have been able to satisfy equation (10). The left-hand member of the equation then is constant and its value

$$\frac{2\,d\,D}{N'} = \frac{2 \times 3 \times 12''}{21} = 3.428''$$

will, by method of trial and error, have to be satisfied by changing α and β in

$$\frac{1}{\cos \alpha} + \frac{R'\,P'\,M'}{R\,P\,M} \times \frac{1}{\cos \beta}$$

until the two members of equation (10) are equal.

Three or four attempts may have to be made before the desired angles are found but very little labor is involved when tables of natural cosines and reciprocals are used. The angles α and β which satisfy the equation are found to be 44°-10′ and 15°-50′ respectively.

The diameters of gears, numbers of cutters, and leads of spirals will again have to be found in the same manner as before, to meet the changed conditions. In the last case if the leads are such as cannot be cut by the use of the regular change gears on the universal milling machine, the only recourse is to make new change gears.

In a design of a pair of spiral gears sound conclusions which are the result of theoretical and practical investigation point to the fact that the efficiency of a pair of spiral gears is very appreciably reduced by too low angles of the spirals, and by too low or too high (generally too low) velocities of the rubbing surfaces. When there is a choice in the angle of a pair, equal angles for both gears should be used. The proper velocity of the rubbing surfaces are a function of the following: The load on the tooth and thrust bearings; the materials of which the gears are made; the condition of the surfaces; the lubricant used; and the arc of action which will vary with the angle of teeth.

Although there is limited data of experimental velocities with worm gearing there seems to be a dearth of proven data for spiral gears with varying angles. It has been stated that Mr. Wilfred Lewis recommends that a general average pitch line speed should be from 200 to 300 feet per minute. In all probability there is more difficulty in the design of a durable tooth than in the design of a strong enough one. However, the normal pitch of the teeth must be selected and in any one design it is a function of the magnitude of the load normal to the teeth, the length of tooth, arc of action, shape of tooth, and velocity.

By substituting the proper values in Mr. Wilfred Lewis' expression $W = s\ p\ f\ y$ (found in July Supplement to MACHINERY), and dividing p by 2, a pitch will be found which will meet the average requirements. It is to be noted that the factor, y, in the expression, relates to the number of teeth which in spiral gears should be taken along the normal helix as found in the expression $n = \dfrac{N}{\cos^3 \alpha}$.

In conclusion it may be said that when spiral gearing are properly designed, well lubricated, and run at an efficient speed, they should not be condemned as often as the traditional faddishness of some and conservatism of others seem to demand.

* * *

NEW PLAN FOR IRRIGATION.

Many thousands of acres in the arid regions of the West may be improved by irrigation, but the cost of irrigating canals and leveling the land is something enormous, especially the latter. *Forestry and Irrigation* says that a Wisconsin man has made a valuable contribution to the practice of irrigation in humid regions, and the same applies to arid regions. His method of applying the water to the fields is to convey it to the higher points in a sluice hose, perhaps 15 inches diameter, made of oiled duck with lateral ports which discharge into furrows. The sluice hose may be moved wherever required. Thus no land is required for ditches, and there is no expense for leveling. Less water is wasted than where ditches are employed and the water can be delivered where it is wanted and in any quantity desired.

ENGINEERING REVIEW.

CURRENT EVENTS, TECHNICAL AND MECHANICAL—LEADING ARTICLES OF THE MONTH.

A railroad has been built from mines near Gellivare, Sweden, to Ofoten, on the coast of Norway, which is said to be the most northerly railroad in the world. It was constructed by English capitalists, who wanted a supply of Swedish iron the year around.

The bronze propellers of the twin-screw steamship *Kaiser Wilhelm II.*, are 22 feet 10 inches diameter. Each propeller is driven by two four-cylinder, three-crank quadruple expansion engines of 20,000 horse power, making the total propelling force of the vessel 40,000 horse power.

The firm of Robert Poole & Son Co., Baltimore, Md., recently cast a gear wheel weighing 65,000 pounds. The teeth of this gear, as of practically all the gears made by this company, are of the epicycloidal form. Since casting the heavy gear they have cast a smaller one having a pitch diameter of about 9 feet and only 31 teeth. The circular pitch is 11 inches—the largest they have ever made.

As a test of what a modern battleship might do in times of emergency or war, the U. S. S. Kearsarge, recently with the European squadron, was directed to cross the Atlantic under full speed, with natural draft. She arrived at Bar Harbor, Me., in perfect condition, having traversed 2,900 miles in nine days, four and one-half hours, at an average speed of 13.1 knots against variable head winds. Enough coal was left to have continued 1,000 miles further.

In mining operations it would naturally be believed that masses of pure metal could be more profitably worked than any other form of deposit, but such is not the case with copper. In the Calumet and Hecla copper mines in Northern Michigan, great masses of pure copper have been found, and it has proven very expensive to handle on account of the great difficulty of working it with tools and the impossibility of breaking it up by blasting. One mass of over 500 tons of virgin copper was such an expensive undertaking to remove that it was a debatable matter whether it would not be more profitable to abandon that section of the mine for other portions that could be worked easier and more profitably.

In a paper read before the American Foundrymen's Association at Milwaukee, Wis., June 9-11, by W. E. Dickson Sharpsville, Pa., it was stated that pig and cast iron borings lose perceptibly of their sulphur contents after standing for some time, even if contained in sealed bottles. The phenomenon is not noticed in steel turnings, and the difference is attributed to the fact that in cast iron borings every particle is cracked throughout so that a large surface is exposed to oxidizing influences; the steel borings or turnings roll up into a compact mass without cracks, so the surface exposed to the atmosphere is relatively much less.

The production of platinum from domestic ores in the United States decreased from 1,408 ounces, valued at $27,526, in 1901 —the largest output recorded—to 94 ounces valued at $1,814. The domestic supply of platinum in recent years has been obtained as a secondary product chiefly from gold placer deposits in Trinity and Shasta Counties, California. It is reported that the metal occurs, though not in commercially rich deposits, in many other gold placers of California, as well as in Washington, Oregon, Idaho, Montana, Colorado, and Alaska. The Russian sources of platinum supply, which furnish about 90 per cent. of the total consumption of the world, are comparatively limited. The imports of platinum into the United States during 1902 were valued at $1,987,980, showing how small a percentage of the quantity used is obtained in this country from our own mines.

Electric automobile chairs will be one of the features of the World's Fair at St. Louis in 1904. The chairs will have a uniform speed of three miles per hour, the operator having no control over the speed. The chair takes the form of a low phaeton without a cover. There are two large rear wheels and two small ones under the foot rest, all pneumatic-tired. On the inside of the chair, attached to the arm, is a lever, which puts the chair in motion or stops it at the will of the rider. A long lever attached to the front truck has its handle directly in the center of the chair and is used for steering. A feature of the machine is a "sensitive rail" which surrounds the chair on all sides, save at the rear. This prevents any accidents, for when the rail comes in contact with any object, even though it weighs but a pound, it presses against a device that locks the wheels and brings the chair to a dead stop.

The retirement of Rear Admiral Melville from his active duties as Chief of the Bureau of Steam Engineering and Engineer-in-Chief of the United States Navy, through the government requirements as to age limit, brings to a close a remarkable career in the public service. The Rear Admiral is only 62 years of age and is vigorous, so that it is to be hoped he still may have special commissions to carry out for the government and that his ripe experience may often be drawn upon in the advancement of sound engineering principles, progressive, yet conservative, for which he has always stood. It is to be regretted that he could not have remained at his post a few years longer now that the advent of the water-tube marine boiler is at hand and the possibility of the steam turbine for naval vessels may shortly be realized. Admiral Melville began his duties as engineer at a time when the only modern vessels of the navy were the original John Roach ships of the white squadron, having a speed of from 14 to 16 knots. From this small beginning he has directed the engineering features of our whole navy, and these constitute the splendid and unusual record of his more important engineering work. He was a member of the engineer corps during the civil war, and later had many thrilling experiences in connection with several Arctic expeditions, among them the search for the missing crew of the ill-fated *Polaris* and as an engineer officer of the tragic expedition of the *Jeanette*. At present Admiral Melville may be regarded as one of the three or four engineers who are at the head of the engineering profession in its various branches.

The destruction by fire of a train of cars in the subway at Paris, France, last month, and the deplorable loss of life in consequence, has led people of New York City to speculate on the possibility of a similar catastrophe in the new subway of this city. In commenting on the event the *Street Railway Journal* says:

The most conspicuous feature of the new subway cars, which are being built for the New York subway, is the precaution taken to guard against accidents through fire, collision or derailment. The cars were built unusually strong, and were designed especially with the view of withstanding heavy impact. The plans for the electrical features were also made to provide against the possibility of fires from defective wiring, faulty insulation and improper installation of apparatus. A careful study of car construction in European cities, especially with reference to tunnel operation, was undertaken at an early stage, and an earnest effort was made to avoid the defects which have been revealed in former installations. The New York subway management has profited by the experience of the London and Paris companies, and those who are best qualified to judge say that such a disaster as the Paris conflagration could not be repeated in this city. Not only has every effort been made to insure safety by employing fireproof material, including a copper sheathing for the car body, but the tunnel construction and equipment show marked advance. Moreover, the lighting service is entirely independent of the power supply for the operation of the trains, a condition that did not exist in Paris.

THE VARIOUS EDISON INDUSTRIES.

A recent issue of the *Electrical Review* contains a description of the Thos. A. Edison works at West Orange, N. J., where are located Mr. Edison's laboratory and experimental departments. While Mr. Edison's fame as an inventor is world-wide and his name is probably known by more people than that of any other living inventor, we doubt whether people are generally familiar with the fact that Edison is also a large manufacturer. There are several Edison plants in New Jersey, turning out a variety of products and in large quantities. At the West Orange works are manufactured nearly all of the parts of the various machines made for the different selling companies which represent the Edison interests. Here are made the stampings and turnings for the Bates and Edison numbering machines, fittings and appurtenances for the Edison phonograph, the Edison kinetoscope apparatus, and some of the material which goes into the assembling of the Edison primary battery and the Edison primary battery fan motor. While the primary battery is assembled at the works at West Orange, the manufacturing of the parts is mostly all done at Silver Lake, N. J. The manufacture of these several products constitutes an immense business, as can be judged when it is considered how many Edison phonographs alone are in use in every part of the country. There is still some experimenting being done on the Edison storage battery at the West Orange works, but the machinery, outside of the experimental machinery, is being put up and placed in operation at Glen Ridge, N. J. Mr. Edison is also interested in Portland cement works and experimental machines for them are being constructed at the experimental department at West Orange, but the heavy machinery and manufacturing equipment for this plant are located at Stewartsville, N. J.

SLEEPING CARS FOR ELECTRIC LINES.

The development of interurban electric lines in all parts of the country, and particularly in the Central West, is becoming nothing short of remarkable. The convenient service which such roads are able to render, the cheap fares and reasonably quick running time; the frequent stopping places, the neat and attractive cars, and the ability of the cars to enter the various towns and cities on the tracks of the regular street railways render the interurban lines justly popular. That they are to encroach still further upon the domain of the steam lines is evident from the fact that preparations have been made for sleeping cars on some of the interurban roads where the length of run is sufficient to make them profitable. It is expected that the new sleeping car service will be patronized largely by traveling men, who find the schedules of the older roads inconvenient for travel by night. These roads run their best trains for the benefit of through traffic, and their times of departure from many cities, midway between main destination points, is at almost any inconvenient time of the night or early morning. A traveling man has to work and work hard daytimes, and does not like to take a train at two o'clock in the morning and lose half a night's rest in order to be on hand for business at the next station the following day. The Holland Palace Car Company, Indianapolis, Ind., has recently been organized for building sleeping cars for electric lines. Their car differs radically from the Pullman design, but may be used, like the Pullman car, as a day coach as well as a sleeper. All of the partitions are made on the principle of the roller top of a roller-top desk, and slide down between the double floors in the daytime. These partitions are in front of the berths, as well as at the ends, except for a narrow opening for entrance and exit, which is covered by a portiere. The berths are 27 inches wide, and there are 15 inches between the edges of the berths and the front partitions, giving standing room within the compartment itself. Two cars are nearly finished and will be used on lines in Ohio and Indiana.

LARGE TURBINE PLANT.

The *Western Electrician* states that the Edison Electric Illuminating Co., Boston, Mass., is about to erect on L Street, South Boston, a new electric light station, which, when completed, will constitute one of the most important and, in point of equipment, one of the most modern in the country. The particular feature of interest is that turbine units are to be installed instead of reciprocating engines, coupled to generators.

The station, consisting of a boiler room, turbine room and switchboard room, will be built upon the "unit" system, comprising 12 distinct units, each of which will have its own steam and electrical equipment, as well as individual auxiliaries, so that each unit will be virtually a station in itself, arranged to run independently or in conjunction with any or all of the others. These sections will be built and added to from time to time, as the increasing business of the company requires, until finally the building will cover an area about 650 feet long and 250 feet broad, which is nearly four times the area occupied by the present station building, while the plans call for an ultimate equipment in boilers equal to an engine capacity of 96,000 horse power, and an electrical capacity of 60,000 kilowatts, which, together with the 9,000 kilowatts already installed in the old station, will provide a total of 69,000 kilowatts (or 92,000 horse power), available from the L Street station.

The installation will consist of Babcock & Wilcox boilers, rated at 500 horse power each, and 5,000-kilowatt General Electric steam turbines, to each of which will be direct-connected one General Electric, three-phase, 60-cycle, 6,900-volt generator of the same capacity. To facilitate the handling of heavy pieces of machinery, there will be installed, in the turbine room, a 50-ton electric traveling crane. The walls up to the level of the crane track will be lined with tiles, while the space above will be finished in fancy brick.

Beneath the turbine room, running its entire length and extending to the water of the channel, will be constructed three brick-lined tunnels, two having a diameter of 8½ feet each, for the intake of water for condensing purposes, and one 10 feet in diameter for its discharge. The lower inside surface of these tunnels will be about 30 feet below the level of the floor, and their construction will require, to a certain extent, the same class of engineering necessary in the building of the East Boston tunnel. Towering above the station, one common to each consecutive pair of units, will be seen six graceful chimneys, 250 feet high, each 25 feet in diameter at the base and with a minimum internal diameter of 16 feet.

THE EDISON BATTERY.

At various times adverse comments upon the Edison storage battery for automobiles have been made by writers in the technical press, and we remember a discussion by one electrical engineer who demonstrated to his own satisfaction, and perhaps to others, that the battery simply could not be any better than any of the lead storage batteries on the market, for the reason that it was no better in principle, and in fact had serious faults of its own. Time alone will prove the truth or falsity of this assertion, but be it said that Edison himself has full confidence in his battery and his confidence apparently is based not only upon theoretical grounds but upon practical results of extended trials. Reporters of the *New York Times*, the *Newark (N. J.) Evening News* and the *Electrical Review*, New York, have recently interviewed Edison upon the subject. Edison contends that American automobiles are not built substantially enough for hard usage and at present is about to construct four automobiles complete, modeled along French lines, but equipped with electric motors and his batteries instead of with gasoline motors. With these he expects to be able to subject his batteries to even harder and more severe tests than they have yet had.

The following points were brought out by the reporters: There are now three heavy trucks operated by current from the Edison battery. One is a two-ton truck which formerly had over 1,200 pounds of lead battery. It is now equipped with about half this weight of the new battery, which will carry the truck 35 miles before the voltage begins to fall off. In one test a battery was used in a runabout for a distance of 5,000 miles, being recharged over and over again with electric current and at the end showed no deterioration of its component parts, and appeared to be good for an indefinite amount of use. At present one set of batteries is being made a day. Recent improvements enable the battery to be charged even more

rapidly than possible with the earlier types, which had rapid charging as one of their characteristics. This has necessitated changes in the fixtures and machines for manufacture. Another difficulty in putting the battery on the market has been the trouble in getting the kind of sheet metal needed. This is now imported, under a heavy duty, but a rolling mill will be in operation in this country this fall for its production. The present cost of the battery is fixed at $15 a cell. Four cells are required per horse power hour, and twenty-one cells are installed in the ordinary runabout machine, which they will drive for 81 miles on a single charge. Thirty-eight cells will drive a machine weighing one ton 60 miles, and a delivery wagon weighing two tons will go 36 miles on one charge of thirty-six cells. Mr. Edison confidently predicts that within a few years the gasoline machines now in use will be entirely replaced by machines driven by electric motors actuated by his batteries.

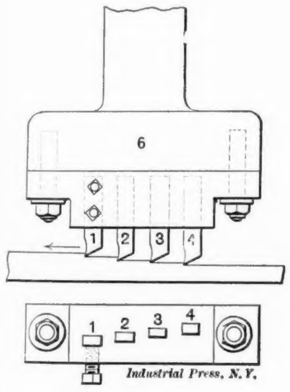
THE BIGGEST HARVESTER IN THE WORLD.

World's Work, August, 1903.

Last year there was in operation in the San Fernando Valley of California the largest combined harvester in the world. It consists of a traction engine capable of hauling seventy-five tons and which takes the place of sixty horses; a header or mowing machine which cuts a thirty-six foot swath, and a complete threshing machine. The header and threshing machine are run by a separate thirty-horse power engine getting its steam from the same boiler as the threshing engine. The drive wheels of this monster traction engine are eight feet in diameter, with tires forty-eight inches wide on which are ridges an inch and a half high. It can average three and a half miles an hour in good grain. The thresher has a capacity of 100 acres a day. Eight men are employed on the thresher. The grain is threshed clean and finally carried to a bin from which it is sacked. When twelve sacks have been filled they are allowed to slide off the cart to the ground. This huge machine will work equally well on level or hilly country, having sufficient power to take a twenty per cent. grade without difficulty. It is sixty-six feet long, half as wide, and weighs more than 100 tons. Oil is used as fuel. This harvester has been successfully used for shelling peas and beans as well as grain. It is purely a Californian production.

GANG PLANING TOOL.

Zeitschrift fur Werkzengmaschinen und Werkzenge, January 15, 1903, p. 163.



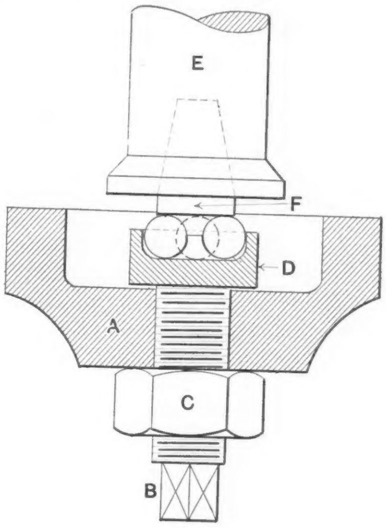
Gang Tool.

The gang cutting tool has gained for itself a prominent place in German shop practice, and the accompanying illustration shows one that is doing good work. The construction will be readily understood from the drawing. The cutting tools 1, 2, 3 and 4, are inserted in the holder and fastened by setscrews. The holder itself is attached to the tool post or carriage by bolts, thus making it possible to remove and replace it with great ease and rapidity. By this means the cutters can be taken away and ground to the proper dimensions and shape without disturbing them in their position.—G. L. F.

A STEP BEARING.

Zeitschrift fur Werkzengmaschinen und Werkzenge, January 15, 1903, p. 158.

This step bearing is acting very satisfactorily upon a number of vertical shafts running at high speeds on woodworking machinery. It consists of a cup-shaped base, *A*, which is integral with the frame of the machine. This base is threaded for the screw *B*, which is fastened by the check nut *C*, and serves to support the cup bearing *D*, in which the balls are placed. The spindle *E* rests upon these balls through the intervention of a hardened steel bearing block *F*. This latter is let into the spindle with a taper fit and is driven home. The arrangement thus provides a ball bearing for the foot of



Ball Step Bearing.

a spindle with a vertical adjustment that can be made at any time without difficulty, while the actual bearing parts admit of quick and ready renewal.—G. L. F.

TEST OF HIGH-SPEED TOOLS.

L'Echo des Mines et de la Metallingie, February 16, 1903, p. 185.

Some interesting tests have recently been made by Yarrow & Co. with drills made of common and special tool steel, for the purpose of ascertaining the maximum speeds at which they can be run, their relative endurance and the power required to drive them.

It was found that the common steel could not be run at a speed greater than 76 revolutions per minute with a feed of 1-200 inch, while the special steel could be run at a speed of more than 100 revolutions. The relative endurance of the two classes of drills was estimated from the increase of power required to drive them after a certain amount of work had been done. It was found that, with the special steel, there was an increase of 8½ per cent. in the amount of power required to drive them after thirty holes had been drilled at a speed of 96 revolutions per minute, while, in the case of the drills made of common steel running at 76 revolutions per minute, an increase of 37¼ per cent. was required.

It was found that drills 1¾ inch in diameter could be worked in soft steel at a speed of 100 revolutions per minute without difficulty. Hence, in order to obtain the most economical results in drilling, a special steel must be used.—G. L. F.

TRAIN RESISTANCE AT HIGH SPEEDS.

Zeitschrift fur Electrotechnik, March 1, 1903, p. 127.

In a formula worked out by Herr J. Davis he considers that: 1, the friction of the journals is independent of the speed; 2, the friction of the rails is in proportion to the speed; 3, the air resistance is in proportion to the square of speed and is also dependent upon the shape and size of the car and the number of the same in the train.

Experiments were made with a train consisting of a locomotive, a brake van and four cars, noting the results obtained with the locomotive alone, the locomotive and one car, the same with two cars, etc.

The curves that have been plotted from these figures may be represented by the formula:

$$S = \frac{4 + 0.13V + 0.004AV^2\,[1 + 0.1\,(n - 1)].}{T_1}$$

where

S = the train resistance in horse power per ton;
V = the speed in miles per hour;
A = the cross sectional area of the car in square feet;
n = the number of cars in the train inclusive of the locomotive.—G. L. F.

HIGH-SPEED STEELS AND THEIR USE FOR CUTTERS OF COMPLICATED SHAPE.

Abstract from paper read by Edmund L. French before the American Society for the Advancement of Science.

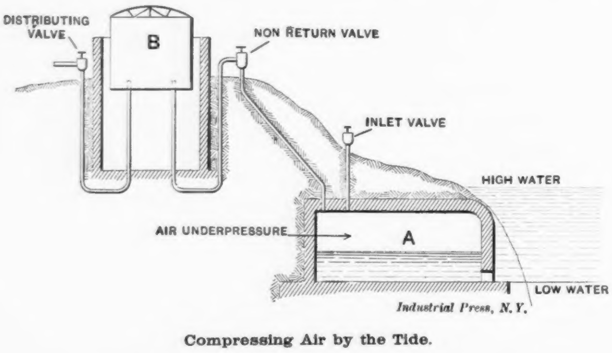
These high-speed steels have worked a complete revolution in modern engineering, necessitating the building of new and more powerful machine tools, and nearly doubling the output of shops where they have been adopted. All the best makes of high-speed steels show ability to withstand the heat engendered in heavy lathe and planer work to such a remarkable degree that it is a common sight in machine shops where the latest high-speed steels are used to see a tool doing heavy cutting work with that part of the steel where the chip curls off actually red hot. Here comes in the distinction between a plain carbon steel and the high-speed self-hardening product. When a tool made of the former becomes so heated by work as to show the temper colors, it softens, and the cutting edge is quickly rubbed off, while a high-speed tool similarly heated retains sufficient hardness to do the work required.

Until recently the extensive use of self-hardening steel has been confined to extremely simple forms of tools, where all the work necessary to fit them for service could be done by forging and grinding to shape. Now, however, there have been perfected processes of annealing which admit of self-hardening steel being as easily machined as most of the ordinary carbon grades. The high-speed qualities of the steel, as found in lathe and planer tools, can thus be utilized for cutters of all kinds, complicated or simple in pattern, at a great saving of time through the increased amount of work such tools are capable of turning out. The greatest advantage, however, which such a steel possesses over the ordinary water-hardening varieties lies in the fact that there is absolutely no danger of loss in the hardening bath, where so many costly tools meet their end, for it is only necessary to heat such a steel to redness and lay it aside to cool, when it will have regained the hardness it possessed before annealing.

MEANS FOR UTILIZING THE POWER OF TIDES.

Compressed Air, July, 1903, p. 2460.

The plan of Mr. Charles Eugene Ongley, of Mons, Belgium, for utilizing the power of tides, is to build a subterranean chamber at right angles to the shore line which shall be connected with the ocean by an opening at the low water line and low in height as compared with the rise of the tide and the total height of the chamber. The rise of the tide by virtue of this construction, imprisons air in the chamber and subjects it to pressure which depends upon the difference in height between the tide level and the level of the water in the chamber. Thus if the high tide level were six feet



Compressing Air by the Tide.

higher than the level of the water in the chamber the pressure per square inch would be approximately three pounds. This pressure, while comparatively slight, can be raised to higher pressures by means of accumulators working on the well-known principle employed in hydraulic accumulators for presses, riveters, etc. In the cut, *A* is the subterranean chamber communicating with the sea. The roof of this chamber is supposed to slope upward away from the water so that the imprisoned air has free access to the pipe leading to the air-holder *B*. This air-holder works on the same principle as the well-known gas-holder and serves to store the power and distribute it over those periods when the tide is falling, etc. The chamber *A* need not necessarily be located immediately at the water's edge; it may be connected with the sea by a suitable tunnel as well.

TEST OF DIFFERENT METHODS OF JACKETING LOCOMOTIVE BOILERS.

Revue Generale des Chemins de fer, February, 1903, p. 91.

A series of experiments, made at the shops of the Paris, Lyons & Mediterranean Railway, on the radiating qualities of different methods of jacketing boilers, shows that in the matter of the influence of surface on heat radiation as far as the metals themselves are concerned either dull or polished brass is to be preferred to any of the others. It was also found that polishing makes a sensible diminution in the amount of heat radiated, and thirdly, that if a coat of paint is applied, the character of the sheet has no influence whatever. The radiation is governed by the painted surface only, and the loss is considerably greater than with the bare surfaces.

The work also included tests of different methods of jacketing in calm air as well as where there were currents.

The bare jacketing radiated less than the painted, the difference being from 55 to 185 heat units per square foot of surface per hour. In calm air and under the same conditions, a single jacket of mineral wool radiated about one-half as much heat as a bare jacket, and one-third as much as a painted one. Where a double layer of mineral wool was used, the losses per square foot were about one-half as much as they were in the case of the single layer.

With a double jacket and a layer of mineral wool between, the losses were about one-half as much as they were with a single jacket without the wool.

It was found that in air currents when the velocity was greatly increased the losses were doubled, and that a layer of mineral wool reduced these losses by one-half. The effect of painting is to increase the loss but not to so great an extent as in calm air.

A further test was made of pipe coverings, using a copper pipe 7 inches inside and 7½ inches outside diameter and about 7 feet high; the comparison being made with a bare pipe and one having a brass jacket enclosing a covering of one or more thicknesses of corrugated paper, the whole being wrapped with a sheet of tarred paper.

The results obtained in condensation of water per hour under the same conditions, the pipe being vertical, in free contact with the air and connected to a boiler carrying a pressure of 213 pounds per square inch were as follows:

	Pounds.
Bare pipe	25.3
Pipe with special covering	15.4
Pipe enclosed in brass jacket	16.5

G. L. F.

DEVELOPMENT OF TOOL STEEL.

Edmund L. French before the American Association for the Advancement of Science.

The author stated that the hardening of steel dates back to the remotest antiquity, the name of the original inventor or discoverer having been lost to the world. The ancient Egyptians made a low grade of steel capable of being hardened by heating meteoric iron for a long time in the forge, during which period it absorbed sufficient carbon from the fuel to harden when plunged into water. The metal-workers in the dark ages also hit on the same discovery and this was the actual birth of the steel industry and the beginning of the development of the crucible process.

The progress of steel-making as an art, until within the last two hundred years, was slow but gradual. Weapons of war and rough implements for tilling the soil were for centuries fashioned by skillful smiths who worked at isolated forges, and who guarded their mysterious secrets carefully and well. Gradually, however, as a demand grew for fine swords and armor of steel, axes, knives, and other tools, these steel workers formed themselves into colonies for trade purposes at places where good iron could be easily obtained, and the industry developed to a commercial scale. Notably in Austria and England this centralization took effect, and in

the city of Sheffield large furnaces were in operation in the seventeenth century for the conversion of Swedish and Norwegian iron into blister steel by the cementation process.

This process was essentially the same as that employed by the ancient workers of iron, but on a larger scale, with furnaces especially built affording facilities for converting the pure iron bars into steel in quantities which soon made the industry an important one. Although the industry grew rapidly, and the product was of such a quality as to permit of the manufacture of the finest tools, these old steel makers worked on a "hit-or-miss" plan, with no clear idea of the way and wherefore of their process. A steel was obtained which had uncertain percentages of carbon, higher on the outside than on the inside, and varying in hardness from one end to the other, according as the bar came in contact, in the converting furnace, with more or less of the carburizing material or a higher or lower degree of heat.

It was not until about 1730, when Huntsman, of Sheffield, the inventor of the crucible process, began to make his experiments, that the industry was actually born. Huntsman's invention grew out of the necessity for a more uniform product than that afforded by the cementation process alone—in fact, for a metal of absolute homogeneity. He conceived the idea of cutting the blister bar in pieces and melting it in crucibles to get a uniform carbon. The charge was then allowed to cool and the crucible broken away from the mass of steel, which was used as an ingot. Molds for casting the metal were subsequently introduced, thus saving the crucible for further use.

Huntsman's process of melting materials in crucibles was not new. His invention really consisted in successfully solving the great difficulties met in applying his process to the actual production of steel, and it is thought probable that his knowledge and skill in producing crucibles of a sufficiently refractory nature to withstand the high heat required, were responsible for his success. The new process developed by Huntsman, and improved on by such men as Jessop, Mushet, Lucas, Sanderson, Spencer, and others, soon gave to England the first rank among steel-making nations, and made the name Sheffield a synonym for the best that was known in the form of a razor, a knife, or a bayonet.

Then the crucible-steel industry was started in other countries, but there have been no important changes in the essential processes of crucible-steel manufacture. An advance over the use of the cemented bar has taken place in the American practice largely in vogue of using a highly carburized and very pure iron, called washed metal, as a vehicle for introducing carbon into the steel, giving more regular percentages than can be obtained by the use of charcoal, and lowering the cost of making without any deterioration in quality.

It is along the line of special steels or alloys made in the crucible that the greatest advances have taken place. The makers of the old-fashioned crucible steel found that when they had produced a material with the highest amount of carbon possible, quality being at the same time of the best, they had reached the limit of cutting power in tools, and competition made it necessary for each maker to attempt something to excel his neighbor's product.

The first great advance was made by Mushet, who succeeded in melting with his charge of steel the mineral "wolframite," which gave him certain regular percentages of tungsten and manganese. The steel so produced had the peculiar property of being "self-hard"—that is, of requiring no heating and subsequent cooling in water to induce hardness. It had also an ability to withstand the heat developed by friction in cutting work, and the product, called "mushet," which name is still used in some localities to designate this variety of steel, became a recognized institution. As soon as the chemist found out the ingredients of this new steel, the various makers began to imitate it.

Tungsten metal and ferro-tungsten were later made to facilitate the manufacture, and gradually chromium, molybdenum, and other metals were employed in the production of this class of steel. Even uranium, titanium, and vanadium are used to some extent to-day as ingredients of special crucible steels. A large variety of combinations of iron and carbon with tungsten, chromium, manganese, nickel, silicon, or molybdenum characterize the special steels on the market to-day. Every maker furnishes, besides his regular carbon steel, a self-hardening steel and an intermediate grade which may be called a semi-self-hardening. The latter is capable of being hardened in water without cracking, and suited for extremely hard cutting. The self-hardening steels cannot be brought in contact with water while hot on account of the danger of cracking. Some of the milder grades rely on the assistance of an air blast, after forging, to give them the proper degree of hardness for their work, and are called "air-hardening steels."

It was thought for years that the greatest degree of perfection and the limit of cutting power had been reached in the best self-hardening steels, but within the last three years new products, similar in character and analysis, have been perfected, with capabilities of high-speed work which far surpass the old. Many of the latter steels owe their high-speed qualities to special heat treatments given the tool after forging, while some of the newer products are of such combination chemically that no treatment, or only a simple one, is necessary.

TESTS OF THE RATEAU STEAM TURBINE.

Street Railway Journal, July 25, p. 118.

The steam turbines designed by Prof. A. Rateau, Paris, France, and manufactured by the Oerlikon Machine Works, Switzerland, and Sautter, Harlé & Co., France, are assuming a prominent position and appear to give good results. Their operation is similar in principle to the Curtis turbine in this country. In his tests Rateau determines the efficiency from the ratio of the real steam consumption to the theoretical consumption of an ideal machine. The theoretical steam consumption is defined as corresponding to the maximum work which the steam can produce under the conditions under which it is delivered to the machine, by expanding adiabatically and without losses, from the initial pressure to the exhaust pressure. Prof. Rateau shows that the theoretical consumption depends largely upon the pressure in the condenser, as shown by the following example:

If a machine using saturated steam at a pressure of 213 pounds per square inch exhausts into free air, the theoretical steam consumption is 12.85 per horse power hour. If, however, the same machine be provided with a condenser which reduces the exhaust pressure to 27 inches the theoretical steam consumption is only 7.82 pounds, i. e., 39.3 per cent. smaller than before.

Following are the results of some tests of a turbo-generator of 540 electric horse power, which is one of a group of three similar machines made in the Sautter-Harlé works for the Penarroya mines in Spain, where they have just been installed. Each set consists of two turbines of high and low pressure, and two direct-coupled direct-current dynamos, giving each at normal load 830 amperes at 220 volts. The normal speed is 2,250 revolutions per minute. These turbines operate condensing, with "ejector" condensers of the Rateau type. The boilers supplied steam under a working pressure of 140 pounds to 210 pounds, maintained at the turbines by a reducing valve at 140 pounds per square inch as maximum. The consumption and the efficiencies are given in the following table:

TESTS OF RATEAU TURBINES.

	¼ Full Load.	½ Full Load.	Full Load.	Over-load.	Over-load at 2,400 r. p. m.
Electric horse power at the brushes	135	259	525	627	641
Working pressure at gage in lbs. per sq. in............	31.	61.	12.1	141	141
Absolute pressure in lbs. per sq. in. of exhaust........	1.247	1.34	1.64	1.82	1.82
Theoretical consumption in lbs.	10.91	9.77	8.82	8.71	8.71
Actual consumption in lbs. in horse-power at the brushes	21.3	18.0	15.74	15.31	14.86
Combined efficiency of generating set	0.513	0.540	0.560	0.569	0.586

This table shows that the combined efficiency, i. e., that of turbine and dynamo together, varies between 51 per cent. and

58.6 per cent., while the steam consumption per electric horse power hour may be as low as 14.86 pounds. Also, that the combined efficiency of the turbo-generator is practically constant, the variations being not more than 8 per cent. between overload and one-quarter full load.

The efficiencies of turbines when a high vacuum is used suggested to Prof. Rateau the possibility of utilizing, by their means, the exhaust of steam from engines running at intermittent load, such as steam hammers, mine hauling and rolling mill machinery. In such cases to secure a continuous flow of steam to the turbine Rateau uses an apparatus which he calls a "regenerative accumulator of steam;" it consists of sheet-iron cylinders, containing a series of cast-iron plates, which condense the steam on its arrival from the prime mover and allow it to vaporize when the exhaust from the first machine stops. The pressure of the exhaust steam is nearly constant, and equal to about 3 pounds. An adjustable valve, regulated by hand, permits a variation within certain limits of the steam pressure from the accumulator; in general this pressure is from 2.8 pounds to 5.2 pounds.

A very interesting application of this principle has been made at the Bruay mines at Pas-de Calais. The exhaust steam of the hoisting machine is fed to a turbo-generator of 300 horse power. The test showed a production of 1 electric horse power per hour at the terminals of the generator, with a steam consumption of 39.68 pounds; the steam being admitted at atmospheric pressure and the vacuum in the condenser being 24.8 inches of mercury, hence, relatively bad. This figure Professor Rateau believes could be reduced to 28 pounds per electric horse power hour with a better vacuum in the condenser, which is perfectly obtainable in practice. Under these conditions the low-pressure generating set performed about three times as much useful work per pound of steam as the hoisting machine, even with a steam consumption of 30.68 pounds against 100 pounds, the ordinary figure for a simple non-condensing hoisting engine.

STEEL, AND STEEL AND CONCRETE TIES.

Railway and Engineering Review, August 1, 1903, p. 580.

Now that railway and government authorities have become thoroughly aroused to the question of future timber supply, any measure undertaken with a view to conserve this supply, increase the life of timber that is used for structural purposes, or substitute other material, wherever timber is in demand in large quantities, is necessarily a subject of a good deal of interest.

The thought of using iron or steel in substitution for wood in structural work comes naturally, and in foreign countries there is a large mileage of track laid with iron or steel ties. In this country experiments with steel ties, in years past, have been unsatisfactory, principally owing to the fact that the designs which have been tried have failed to properly support the track and to admit of surface repairs by ordinary methods of track work. The general rise in the price of steel a few years ago also had the effect of turning the attention of railway men from the use of this material for railroad ties. Within recent years a few men have proposed the use of concrete reinforced with steel.

The man who has labored most persistently along these lines, so far as we are aware, is Mr. C. Buhrer, roadmaster with the Lake Shore & Michigan Southern Railway, at Sandusky, O. Three years ago Mr. Buhrer laid some steel ties in the main track of this road at Sandusky, and a year later other ties of the same kind were laid on a curve in the main track at Sandusky Junction, about 2½ miles east of Sandusky, where the trains make full speed.

These ties have maintained the track in good surface, alignment and gage, with much less work than has been required for wooden ties under like conditions, and it has been unnecessary to disturb the embedment of these ties to make renewals, as is necessary with wooden ties each season. The piece of track laid with these ties bids fair to remain in first-class condition for many years to come, at an expense for maintenance which is very much less than that required for track laid with wooden ties.

Mr. Buhrer's principal aim in experimenting with these ties has been to ascertain their effectiveness as a track support, and to show a decrease in the amount of work necessary to maintain the track in surface and alignment. The test has proven that his expectations have been realized, and the facts are indisputable. The only remaining consideration of importance is the expense. Owing to the state of the steel market for several years past, Mr. Buhrer has not been able to get the rolling mills to undertake the manufacture of the ties by rolling them from old rails. This would be the desirable method of construction, as then the tie would be in a single piece, and, if they could be rolled out of scrap rails by reheating, without remelting, the same, the expense of manufacture would be a minimum.

In any event the tie could be rolled from new metal, and Mr. Buhrer is ready to demonstrate that, even when so made, the maintenance cost of track laid with such ties can be reduced to a figure much lower than the present cost with wooden ties, with a very satisfactory showing for the ultimate economy.

Mr. Buhrer's experiments with concrete for tie material were begun in June, 1902, when a few ties of concrete, reinforced with a piece of old rail molded in the top face, with the head downward, were laid in the main track of the L. S. & M. S. Ry. 2½ miles east of Sandusky, O., adjoining the steel ties above referred to. Later ties were laid on short lengths of other roads and in every case have proven satisfactory in all particulars. The reinforced concrete tie affords substantial bearing for the rail and a very secure arrangement for the fastenings. As the head of the rail projects downward into the body of the concrete the latter secures a very firm hold of the rail, and a strong and stiff tie is secured. It is fully understood that the use of old rails in these ties involves a good deal of metal, undoubtedly in excess of the requirements; but as the principal aim of the experiments was to determine how the concrete would bear up under the traffic and sustain the shock of rolling loads, the excess of metal was of minor importance. The inventor has in view the possible use of various metal shapes for the top face of the tie, such as old rails of lighter weight than the ones used, which weigh 60 pounds to the yard; T-irons, bulb irons, a channel with the flanges downward, and other shapes.

Mr. Buhrer has made a careful study of the concrete mixture required for tie material, and the result has been a selection of sizes and proportions differing somewhat from ordinary practice in general concrete construction. Methods of mixing and molding have also been evolved to suit the requirements of the material. The experiments cover the use of both fine gravel and finely crushed stone as ingredients of the concrete mixture. After setting 30 days the concrete of these ties is remarkably strong and hard, and will bear smart blows from a sledge hammer without fracture. The ties are unloaded by being thrown from the cars. The only precaution taken is not to let one tie fall across another. Mr. Buhrer says he has no fear of damage to the ties so long as they do not strike anything harder than the ground, and from tests of the material made in our presence it does not appear that they are an article requiring delicate handling. The track laid with these ties can be raised and tamped with bars or picks equally as feasible as track laid with wooden ties, and a misdirected blow or "lick" from a tamping bar does not "faze" the material.

ENGINEERING FEATURES OF A GREAT DEPARTMENT STORE.

Insurance Engineering, July, 1903. p. 27.

The department store of Marshall Field & Co., Chicago, is the largest retail establishment of the kind on this side of the Atlantic and there are only two larger in the world, those being in Paris. The total floor area of the Field store is 1,000,000 square feet, which is about one-third larger than the area of the new Macy store in New York City. The store is composed of several sections, or buildings, one of which, recently constructed, is 12 stories high. Seven thousand people are employed.

There are 53 elevators, of which 41 are for passenger service, all of the improved electric type, operated in most cases by a 35 horse power motor for each. The motors are all located in the attic, so that no space is occupied in the base-

ment by elevator machinery. The passenger elevators have a capacity of 3,000 pounds each at 350 feet a minute and the freight elevators 3,500 pounds at 250 feet a minute.

Considering the large number of lights, and power necessary to properly equip this wonderful store, one would think that economy would lie in having its own power plant. Nevertheless this is not the case. While space has been reserved for the installation of a 3,000 horse power generating plant, the whole plant is operated from the mains of the Chicago Edison Company. The installation for electric light and power supplied from a central station is probably not surpassed in this country or abroad.

The connecting load in this block of buildings amounts to more than 2,800 horse power in motors and an equivalent in light of over 40,000 16-candle-power lights. Reducing the power and light to 16-candle-power equivalent shows a total connecting load of about 82 000 16-candle-power lights.

There are 35,000 16-candle-power incandescent 115-volt lamps and 500 2,000-candle-power arc lamps at 115 volts, with 2,000 extra outlets for special and local displays. There are 2,000 lamps in the display windows on the street frontage. These are arranged in trough reflectors, and so far as outside observation is concerned no lights are in sight.

One can conceive a fair idea of this immense power and lighting system by mental comparison. Marshall Field & Co.'s combined electric light and elevator plant would furnish lights for a city the size of Toledo, Minneapolis or St. Paul.

To light the various cases throughout the store, watertight iron floor boxes are installed, each box being fitted with a brass cover. About 400 of these boxes are installed, having a total capacity of over 5,000 lights. From these boxes tap circuits are run to light up the cases. Considering that the framework of these cases is but ¾ inch wide, the matter of lighting them, concealing the work, and retaining the line of beauty, called for considerable ingenuity. This was accomplished by the use of small specially constructed troughs placed in the upper front edge of the show case, and protecting them from view by means of mirrors about 2 inches wide. In the troughs are placed special small Edison sockets with miniature lamps.

Ventilation is provided for the enormous room in the basement by a system of blowers, which in reality is a combination ventilating and heating plant. During the warmer months it cools and ventilates, while in the winter months the air is drawn over heated pipes and forced into the room heated, thus serving the purpose of a heating plant.

The water system which supplies the 150,000 gallons of water used in this store daily is located in the basement and is equipped with four pumps, run by electric motors, each of which is equal to 100 gallons a minute.

An indication of the amount of business handled through this busy store is shown by the large private telephone exchange installed in the building. The exchange is a branch of the Chicago Telephone Company's system, and is located on the third floor. The switchboard represents the highest type of private branch-exchange switchboard construction, and has all the details as complete as the latest relay central-office switchboard. It is now equipped for 250 private branch-exchange lines and 40 trunk lines leading to the central exchange. The ultimate capacity of these six operating boards will be 400 lines.

The refrigerating plant is operated by 20 horse power brine pumps and two 75 horse power ammonia compressors, all electrically driven. This system has a capacity of 50 tons of refrigeration a day. Cold water is forced throughout the buildings and to the tea rooms for drinking purposes by two 15 horse power motor-driven pumps.

The pneumatic cash-carrier system is operated by two 75 horse power and two 40 horse power motor-driven blowers. There are now some 200 stations installed, and others will be added as fast as found necessary.

For protection, the entire establishment, excepting the annex, is equipped with automatic sprinklers installed by the General Fire Extinguisher Company, Providence, R. I. The water supplies for the sprinklers comprise two 30,000-gallon gravity tanks, four 4,500-gallon pressure tanks, two 1,000-gallon Eastern Underwriter fire pumps, taking 12-inch suction from a 6,000-gallon surge tank, which has an 8-inch connection from the city main.

The tanks are in two batteries, each comprising one gravity tank and two pressure tanks, with a separate 8-inch tank riser running down to the underground pipe, then to a 12-inch header at the fire pump. Each lead from this header has its own indicator gate for shut-off. The system embraces an aggregate of over 2,000 feet of cast-iron pipe in sizes ranging from 4-inch to 10-inch, and connecting to the several risers in each of the two buildings; also to nine Siamese steamer hose connections.

The installation comprises 15,500 sprinklers and is provided with 23 variable-pressure alarm valves and five Grinnell dry-pipe valves. There is also an electric alarm system of gongs throughout the buildings, and annunciator located in the power plant. At every riser shut-off and drain valves are provided on each floor. The first seven stories of the new building have all the pipes concealed, only the sprinklers and the hand-wheels of the valves being visible below the ceiling.

THE BURNING OF PULVERIZED COAL.

C. O. Bartlett in the Journal of the Association of Engineering Societies, July, 1903, p. 44.

To burn coal in a powdered form successfully, three things are necessary, (1) uniformity of moisture, (2) uniformity in size of grain, and (3) the amount of air required for perfect combustion. In my judgment, it is impossible to get perfect combustion by feeding coal in different states of moisture.

First. Coal varies in moisture from 4 per cent. to 15 per cent. During the summer season, especially, ordinary bituminous coal frequently has not more than 4 per cent. moisture, while during the winter and spring or during the rainy season, and especially when the coal is saturated with water and then frozen, the same kind of coal will contain as high as 15 per cent. moisture, and much of this moisture in the form of ice.

Second. It is impossible to get the best results by burning large pieces of coal together with the dust of the coal. The coal must be reduced to grains of equal size and should be 80 mesh fine.

Third. About 140 cubic feet of air are required to burn a pound of coal. The admission of air cannot be successfully controlled by natural draft. Forced draft must be used.

If the three requisites named are secured, perfect combustion can be had, and perfect combustion means no black smoke, no cinders, and very little ashes, and a saving of practically 40 per cent. in the amount of coal used.

A test was made on a 60 x 18-inch horizontal tubular boiler, of about 125 horse power, as follows: First we would run a day on powdered coal, the next day on slack coal and the next day on run-of mine coal. We afterwards made a test of longer duration, running 88 hours on powdered coal and 48 hours on the same kind of coal without drying and pulverizing and by hand firing, and the gross saving was found to be about 40 per cent. in the amount of coal used. Six per cent. of moisture was taken out of the coal. When burning the powdered coal, the amount of ash did not exceed 3 per cent., while in the ordinary way of firing it was a little over 19 per cent.

The first matter to consider in balancing the results of such a test is the cost of drying. Our firm recommends the use of the rotary cylinder dryer, using direct heat, and the products of combustion passing on the outside of the cylinder only. In some few cases the products of combustion are first allowed to pass on the outside of the dryer, then to pass through the coal, and when this is done it is safe to estimate on a basis of 10 pounds of moisture evaporated by 1 pound of fuel, but the operation is not a safe one. I think it is safe to estimate the cost of drying the coal on a basis of 8 pounds of evaporation to 1 pound of fuel. Estimating on a basis of $2 per ton for coal and taking the loss in moisture at 5 per cent., the cost of drying and the loss in moisture will be less than 12 cents per ton. This estimate is based on drying not less than 40 tons a day.

Second, the cost of pulverizing. With one good mill, using 25 horse power, 4 tons of coal can be pulverized in an hour. At the present time there are three systems:

The French Buhr or emery wheel system.

The Huntington or centrifugal type.

The ball or tube mill system.

To these I might add the Kent mill which is now being put on the market, and in which the pressure of the rolls against the casing is obtained by means of screw pressure, which adds to the capacity and at the same time admits of great reduction in speed, adding greatly to the life of the mill. At present it is safe to estimate on a cost of ten cents per ton for pulverizing.

Third. The cost of elevators, conveyors, bins, cost of running blower or feeder, interest on investment, and wear and tear should not amount to more than 10 cents per ton, and probably not more than 5 cents per ton, making the total cost of drying, shrinkage, pulverizing, feeding and cost of driving the machinery, interest on investment, etc., in quantities of 40 tons a day, about 32 cents per ton. This shows, on 40 tons of coal a day, coal costing $2 a ton, a net saving of a little less than $20 a day, or 50 cents per ton.

Another important factor, which I have not considered, is the doing away with the fireman, as in the use of this system no fireman is required. The fireman's wages are therefore saved. Also, there is not more than one-third as many ashes, and there are no cinders at all.

To burn pulverized coal economically it must be burned in fairly large quantities; in other words, I do not think it would pay to put in a drying and pulverizing outfit unless the amount of coal used is at least 10 tons per day. In large cities this difficulty can be obviated by having a central drying and grinding plant and selling the pulverized coal to small consumers. In this case it would be necessary simply to put in a feeder, for feeding the coal in a powdered form, and a tank for holding it.

The next obstacle, and one which I consider of very great importance, is the danger arising from storing large quantities of powdered coal. From the best information that I have been able to obtain I do not think it is practical to store large quantities of pulverized coal for any length of time, and this means that it would not be practical to dry and pulverize the coal at the mines and ship it in this form.

The next question, and quite a serious one, is the construction of the arch. In our experiment we used the Rowe system, which consists in blowing the pulverized coal, by means of an ordinary fan or blower, up against an arch over the fire. The arch wall becomes very hot and immediately ignites the coal, and when the proper amount of air is used the combustion is perfect. We find that a 2-ounce pressure is best for this purpose. It will be readily understood that, in order to withstand this excessive heat, the best kind of arch wall is necessary, and that specially constructed brick should be used. While this is really quite a serious question, I do not doubt that it will be satisfactorily answered. Mr. Fred Siegheim, of Germany, has an invention for covering the arch wall, by which it can be made to withstand a tremendous heat, up to 3,000 degrees or more, without injury, and to last for a long time; in fact, until the draft of air has worn away this material. As near as I can ascertain, this mixture is composed largely of the dust of carborundum, which is now being manufactured in large quantities at Niagara Falls. In taking the matter up with this company, I find that Mr. Siegheim has contracted for the exclusive output of this dust for five years. I consider this a very important invention and well worthy the most careful consideration of the engineers of the United States. It seems a little humiliating that the Germans should get ahead of us, but such appears to be the case.

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ANECDOTES OF THE FAIR OF '46.

"It has not been sixty years since the sewing machine made its appearance in Washington," said an old timer to a "Star" reporter, "and there are quite a number of not very old people who remember the occasion. During the great mechanics' fair, which was held in 1846, opening May 21 of that year, in a specially constructed frame building in Judiciary Square, it was one of the star exhibits. It was said at the time that one of the main objects of the fair was to influence legislation in Congress on the tariff to show what the American workingman could do, and how little we were dependent on other countries for the necessaries of life.

"I remember that the sewing machine was the greatest attraction of the fair and interested the crowds about it, and there was difficulty experienced in getting near it. As may be supposed, the machine at that period had not been brought to the perfection it reached by subsequent improvement, but it did its work to the amazement of the thousands of visitors, and as a labor-saving machine, together with McCormick's reaper, then first exhibited here, caused much discussion. Among the seamstresses the sewing machine was looked upon as the instrument which would deprive them of a living, and it was predicted that its adoption would drive hundreds to poverty. At that time the price was high, and many hoped that so much would be asked for it as to prevent its general use.

"The effect of its introduction was to some extent discussed in the papers of the day, and I believe in some of the manufacturing cities the working people were much excited over the revolution its adoption was expected to bring. I read an abstract of an address by a pastor in one such city, in which he said to the factory people and seamstresses that they had nothing to fear from its introduction. He said notwithstanding so much more sewing could be done by machine, the tastes of the women were such that should the cost of making a dress or other garment be cheapened, more elaborate garments would become the style and there would follow such a demand that instead of taking work from the sewers there would be more. In other words, while the cost of making a plain dress would be lessened, the additional trimmings, extra plaits, seams, etc., would make up for any loss.

"There was no fear that the labor-saving mower and reaper would have such an effect upon the masses," continued the narrator, "for all recognized that should it be effective the cost of daily bread would be lowered. I should mention that the revolving pistol, patented by Colonel Samuel Colt, some ten years before, was an object of much interest, especially to military men, and the fact that it was then on trial in warfare—the Texas Rangers of Captain Samuel H. Walker, engaged in the Mexican War, being armed with the pistols—imparted an additional interest to the subject.

"There were many other exhibits at the fair mentioned, and the display was a revelation to the masses, a great educational object lesson, and probably the most important exhibits were those named. I should not, however, omit to notice another. As is customary, admission tickets were issued to all exhibitors, and hundreds of our younger people were benefited thereby, these being mostly girls who had specimens of sewing, embroidery.

"There was a boy living in the old Second Ward who got up an elaborate aggregation of cogwheels, levers, shafts, etc., so intricate in looks as to bewilder any but the initiated, whose sole object was to obtain an admission ticket. This he entered, but not for a prize, and called it a 'wing wang.' By winding up the motive power, a clock spring, it went into operation with such a clatter as to drown the noise of the larger machines. Curiosity led to many inquiries as to its use, but the only reply obtained was that it would grind smoke, when forced in the hopper, and cool the air with its revolving flippers. Useless though the machine was at the time, it drew the attention of an influential gentleman to the boy, who made him his protege, and the result of the boy's ingenuity was subsequently seen by an improvement in drawbridges and in the matter of lanterns for lighthouses."—*Washington Star.*

* * *

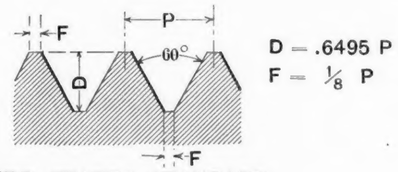
Josef Madersperger, a native of Kufstein in Tyrol, is said to have invented a sewing machine in 1814 which was improved by him in after years so that it was a practical operative mechanism, considering the state of the mechanical arts in that era. But from lack of financial assistance the machine was never manufactured and Madersperger, in common with many early inventive geniuses, never profited by it since history has it that he died a pauper in the workhouse. In after years the worth of his invention was recognized and now the rich sewing machine manufacturers of Vienna, Austria, have unveiled (June 7) a beautiful monument to his memory.

SCREWS.

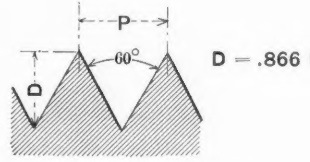
EXTRACT FROM ARTICLE IN THE "MICHIGAN TECHNIC," BY EDWIN H. EHRMAN.

The purpose of this article is to present a series of notes of a practical nature, relating to the several standards of screws, that may be of service to those engaged in machine design or shop management. It is at the outset advisable to review the different forms of screw threads in use, with some note and comment as to their fitness for the various kinds of screws.

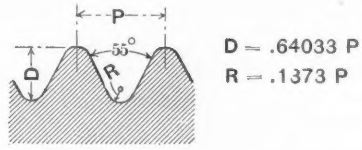
Of the styles of threads in common use in the United States, the United States Standard (also known as the Franklin Institute, or Sellers' form) is the most feasible form to use in the manufacture of screws and bolts. While the thread itself may be a trifle weaker than the sharp V form, it gives a screw



UNITED STATES STANDARD



V STANDARD

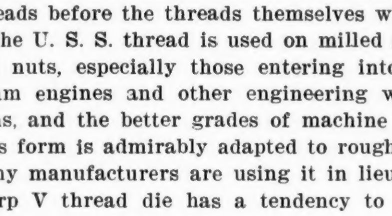


WHITWORTH STANDARD

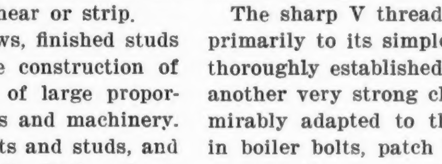
Diameter	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16	1	1 1/8	1 1/4	1 3/8	1 1/2	1 5/8	1 3/4	1 7/8	2	2 1/8	2 1/4	2 3/8	2 1/2	2 5/8	2 3/4	2 7/8	3	3 1/8	3 1/4	3 3/8	3 1/2	3 5/8	3 3/4	3 7/8	4
NUMBER OF THREADS PER INCH.																																					
U. S. Standard	20	18	16	14	13	12	11	..	10	..	9	..	8	7	7	6	6	5 1/2	5	5	4 1/2	4 1/2	4 1/2	4	4	4	4	3 1/2	3 1/2	3 1/2	3 1/2	3 1/4	3 1/4	3 1/4	3	3	3
V	20	18	16	14	12	12	11	11	10	10	9	9	8	7	7	6	6	5	5	4 1/2	4 1/2	4 1/2	4 1/2	4 1/2	4	4	4	4	3 1/2	3 1/2	3 1/2	3 1/4	3 1/4	3 1/4	3	3	3
Whitworth	20	18	16	14	12	12	11	11	10	10	9	9	8	7	7	6	6	5	5	4 1/2	4 1/2	4 1/2	4	4	4	4	3 1/2	3 1/2	3 1/2	3 1/2	3 1/4	3 1/4	3 1/4	3 1/4	3	3	3

that for the same nominal size and pitch is much stronger than the screw with the V form of thread, as the core diameter of a screw with U. S. S. threads is greater by .43 of the pitch than that of a screw with sharp V threads. The increased danger of a screw with U. S. S. form of threads to fail, due to the threads stripping, as compared with that of a screw with sharp V threads, is more apparent than real, as experience has shown that a screw will give way almost invariably by breaking across the diameter at the bottom of the threads before the threads themselves will shear or strip.

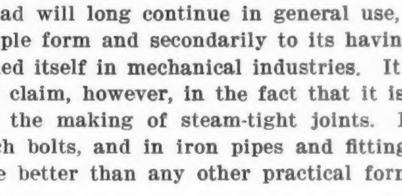
The U. S. S. thread is used on milled screws, finished studs and nuts, especially those entering into the construction of steam engines and other engineering work of large proportions, and the better grades of machine tools and machinery. This form is admirably adapted to rough bolts and studs, and many manufacturers are using it in lieu of the V thread. A sharp V thread die has a tendency to tear the tops of the



INTERNATIONAL STANDARD



BRITISH ASSOCIATION STANDARD



ACME STANDARD

BRITISH ASSOCIATION STANDARD THREAD.

Number	0	1	2	3	4	5	6	7	8	9	10	12	14	19
Diameter, m.m.	6.0	5.3	4.7	4.1	3.64	3.2	2.8	2.5	2.2	1.9	1.7	1.3	1.0	.79
Pitch, m.m.	1.00	0.90	0.81	0.73	0.66	0.59	0.53	0.48	0.43	0.39	0.35	0.28	0.23	0.19

INTERNATIONAL STANDARD THREAD.

Diameter, m.m.	6	7	8	9	10	11	12	14	16	18	20	22	24	27	30	33	36	39	42	45	48	52	56	60	64	68	72	76	80
Pitch, m.m.	1.0	1.0	1.25	1.25	1.5	1.5	1.75	2.0	2.0	2.5	2.5	2.5	3.0	3.0	3.5	3.5	4.0	4.0	4.5	4.5	5.0	5.0	5.5	5.5	6.0	6.0	6.5	6.5	7.0

threads in threading rods or bars that are larger than the finished diameter of the screw; and as bar iron varies considerably in diameter, and is liable to be slightly over size, it has been the custom in cutting threads on it to use dies that are 1-32 inch larger than the nominal size, so that the die will not cut down the diameter of the bar, with the attendant liability of making a poor thread as well as unnecessarily overworking the die. Occasionally the writer has noticed that rough bolts and studs have been threaded even size when the diameter of the bolt was small enough to admit of so doing. This leads to confusion, especially in those sizes where more than one standard of pitch is in use. For instance, in purchasing ½-inch machine bolts one might get ½ inch over size or even size with 12 threads, or ½ inch over size or even size with 13 threads, or ½ inch, 13 threads U. S. S. The adoption of the U. S. S. form of thread would entirely obviate the present difficulty.

In the manufacture of nuts there is the same tendency in threading for the threads to tear if made perfectly sharp, and also a greater liability of the tap breaking from overwork and clogging; consequently, it has become the custom to ream the nut blanks large enough to leave the thread flat, quite as much so as in the U. S. S. form. A valuable point to the manufacturer, both in the making of nuts and in the machine shop, is the greater strength of taps having the U. S. S. form of thread as compared with those having V threads, which means a double economy, due to the longer life of the tap and the greater duty of which it is capable. A good feature of the U. S. S. thread, and one that will bear extending, especially in the smaller sizes, is that it tends toward a finer pitch than the V and Whitworth standards, notably in the ½, 1⅞, 2¼, 2¾, and 5-inch sizes, and it might have been well when the system was planned if the threads per inch for ¼ inch in diameter had been made 22 instead of 20; for 5-16 diameter, 20 instead of 18; and for 1⅛ diameter 8 instead of 7. At present some of our foremost manufacturers of machinery are using ¼ and 5-16 inch screws with the finer threads above noted, styling them the U. S. F. (form) instead of U. S. S.

The sharp V thread will long continue in general use, due primarily to its simple form and secondarily to its having so thoroughly established itself in mechanical industries. It has another very strong claim, however, in the fact that it is admirably adapted to the making of steam-tight joints. Both in boiler bolts, patch bolts, and in iron pipes and fittings it answers the purpose better than any other practical form of thread.

There is no variation at the top and bottom of the thread, as there may be in both the U. S. S. and Whitworth forms of thread, with the resulting liability of leakage through the clearance thus formed. Sharp V threads are used on machine screws, on rough bolts, on boiler bolts, and other bolts where a steam-tight fit is needed, and largely on milled screws.

The square form of thread is usually made about twice as coarse in pitch as the V or U. S. S. threads, and partly for this reason and partly because the perpendicular walls of the thread do not allow the chips to free, it is a troublesome thread to cut with taps and dies. There is also difficulty where more than one cut is made to produce the finished screw, due to the succeeding taps or dies not registering with the partly cut thread, and consequently cutting away the

thread already formed. This form of thread is largely used on adjusting and power conveying screws.

The Acme screw thread was designed to overcome the objectionable features of the square thread. It has many good points, not the least of which is its strength and the ease with which it may be cut, compared with the square thread. This is due to the greater strength of the teeth in both taps and dies, as well as to the facility with which the cuttings free themselves. This thread is advocated as a substitute for, and in preference to, the square form of thread.

The Whitworth form of thread has two points of merit that commend it highly where heavy service is required. First, screws with this form of thread have all of the strength possessed by screws with U. S. S. threads, with the advantage over the latter of having no sharp edges or corners from which fractures may start. Second, screws and nuts with this form of thread will work well together after continued heavy service where the other forms of thread would fail. Whitworth threads are used (in the United States) chiefly on special screws, such as screws for gasoline needle valves where a liquid-tight and yet working fit is desired, also on some makes of ordnance breech blocks.

The standard thread in the International System (*Systeme International*), adopted by the International Congress for the unifying of machine screw threads, held at Zurich in October, 1898, resembles our own U. S. S. thread. The formulas are the same but the pitches are somewhat finer, a distinct advantage, especially in the finer sizes. To provide for a thread with a clearance at the bottom such as is in general use in France, the Congress specified that "the clearance at the bottom of the thread shall not exceed 1-16 part of the height of the original triangle. The shape of the bottom of the thread resulting from said clearance is left to the manufacturers. However, the Congress recommends rounded profile for said bottom." By this wise provision, choice is given manufacturers in the several countries interested to make the bottoms of their threads flat or rounded, as desired, and yet have them conform to a common standard so as to interchange, if necessary.

The S. I. thread has been adopted by the Swiss Union of Manufacturers, the German Association of Engineers and the Society for the Encouragement of National Industries.

The British Association Standard Thread is patterned after the Whitworth, though more acute and shallow, and with larger rounds at top and bottom. The dimensions of screws with the thread are given in mm., the largest being 6mm. in diameter, which is the smallest size of the International system. It corresponds to our system of machine screw sizes smaller than ¼ inch in diameter.

Attention has been drawn to the matter of pitch in the foregoing paragraphs in comparing the several systems of threads, and comment made on the desirability of using finer threads. The pitches of the U. S. S. thread are no doubt suited to bolts used in the larger work in mechanical and civil engineering, but perhaps not quite so well adapted to the screws used in smaller work—especially the sizes of screws below one inch, and there has been a tendency among manufacturers to use screws one, two and even four threads finer than standard. This leads to much annoyance and possibly to confusion, but it suggested a scheme that the writer has adhered to for some years. The plan has been that where a deviation from standard is deemed desirable, the pitch used is one of a range of pitches, the units of which are suited to the different materials and purposes. Out of this scheme, intended to cover the use of screws and nuts only, has developed the system of making all special taps—even to 6 inches in diameter—with one of the following pitches: A pitch of 8 threads is used for screw threads on large pieces and on smaller work where the material is cast iron. A pitch of 12 threads is used where a finer thread is needed and where the material, in part, is brass. This pitch is that commonly used on boiler bolts, planer head bolts, and to a large extent in the nuts fitting on milling machine cutter arbors. A pitch of 16 threads is used where a still finer pitch is wished, and is adapted to adjusting rings, collars and nuts on shafts and spindles used in machinery—especially on hollow spindles used on lathes, drill presses and screw machinery. Other pitches for smaller screws, each pitch covering several diameters, have been established. This has been done largely to enable quick repairs of special cutter heads and holders. The following list explains itself, additional sizes of taps being added as occasion requires:

Machine screw sizes—Nos. 6, 8, 10, 12, and 14, all 32 threads, 7-32, ¼; 9-32, 5-16, 11-32, ⅜, all 24 threads; ¼ to ½ all 20 threads; with isolated sizes of one or another of the above pitches up to 1 inch and 1¼ inches in diameter. The foregoing may be quite unpractical in some shops, but on the other hand the carrying out of some systematic plan in establishing special sizes of screw threads would undoubtedly add to the economy of the tool-room and the machine shop.

Passing from the shop into the drafting room, one finds many ways and means of making and keeping lists of the screws used in the shop for special purposes. In one office will be found large sheets of drawings of screws burdened with a network of dimensions and lines. In another a tabulated sheet is used for each style of screw employed; a drawing of the screw with lettered dimensions above, and below it the table of dimensions with the proper index letter at the top of each column. In still another office will be found descriptive lists of the screws, bolts and nuts used in each machine or article manufactured, with reference numbers indicating the number of the piece or drawing from which each item is taken. Ofttimes a board of mounted samples takes the place of drawing or list. Each system, no doubt, answers the requirements of the office using it, otherwise it would be replaced by a better one; each has its good points, too—from the completeness of the first system to the simplicity of the last.

For special screws and formed pieces that are quite different from stock goods, a drawing of each piece is probably the only way of fully describing it, but for the average screw, resembling in some degree the stock patterns, the most compact record is by tabulated dimensions, referring to a diagram of a typical screw of its class. As one purpose of these records is to facilitate the ordering of screws, it follows that the specifications, drawings, and description should be explicit and entirely free from ambiguities. Many curious screw sheets and blueprints come under the writer's notice, and they lead one to think that either too little thought or too much time and paper has been spent in making them, and they prompt a few comments and general suggestions.

In general—Screws that enter a tapped nole have their lengths measured to the extreme points. (See L, Fig. 1, and X, Fig. 3.) Screws that enter a nut (i. e., bolts and studs), have their lengths measured to the end of the thread, leaving the oval additional. (See L, Figs. 2, 3 and 4.) Measurements of length are made from the outer diameter of the under side of the head. (See L, Figs. 1 and 2.) The diameter of a square or hexagon head is understood to mean the short diameter. The blank part of a screw body is understood to extend to the first marks of the thread, and should measure in cap screws as shown in Fig. 1. (See B, Figs. 1, 2 and 3.) The length of the thread is understood to apply to the useful part of it. (See T and N, Figs. 1, 2 and 3.) Note that the lengths N in Figs. 2 and 3 should not include the partly formed thread made by the leads of the die, as a nut would bind if forced over them. This is true also of cap screws, as shown in Fig. 1. The length of the thread on the tapped end of a stud, however, includes the "lead" or partly formed thread, as the stud when screwed tightly into a tapped hole will enter it practically the whole length of the thread. (See T, Fig. 3.)

Ordinarily.—The length of the blank (B, Fig. 1) part of the body of a cap screw (except for very long screws) is ¼ L. The length of thread (N, Fig. 2) on coupling bolts, is 1½ times the thickness of the nut, where only one nut is used. The partially formed threads made by the leads of the die is, on most screws, about three threads in length; on setscrews and tap ends of studs about two threads in length. The angle A (Fig. 1) in cap and machine screws is 40 degrees. The angle A in boiler patch bolts is 45 degrees. The short diameter of hexagon nuts, both finished and semi-finished, and rough square nuts is equal to $1\frac{1}{2} B + \frac{1}{8}$ inch where $B =$ size of bolt. This is true also of coupling bolt heads (hexagon) which are not finished on their sides. (Ac-

cording to the Franklin Institute Standard this would apply only to unfinished heads and nuts. The diameter of finished heads and nuts would be 1½ B + 1-16 inch). The regular thickness of finished and unfinished hexagon nuts and unfinished square nuts is equal to the diameter of the bolt. This is true also of the heads of coupling bolts.

According to the Franklin Institute Standard, the above would be true only of unfinished hexagon heads and nuts. The thickness of finished hexagon nuts and heads would be B — 1-16 inch. Square heads are not supposed to be finished and their thickness is one-half the short diameter or ¾ B + 1-16 inch. The thickness of check and jamb nuts is ½ B + 1-16 inch, where B is less than 1¼ inch, and ½ B + ⅛ inch where B is equal to, or greater than, 1¼ inch. The diameter is the same as that of unfinished nuts. The length of head for milled screws equals the diameter of the screw. The dimensions of a screw should be expressed in terms of the diameter × the length (diameter first).

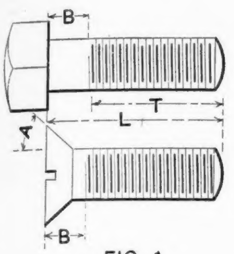


FIG. 1

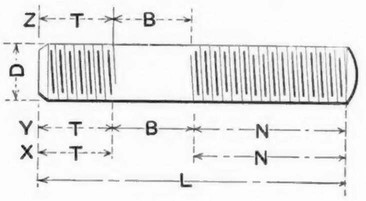


FIG. 3

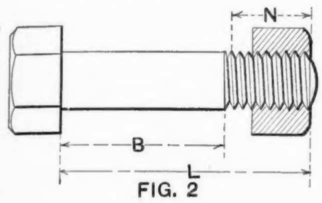


FIG. 2

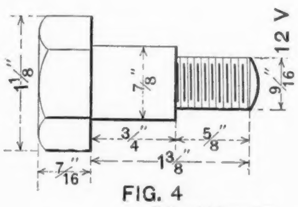


FIG. 4

Industrial Press N.Y.

The fact that the proportions of nuts and screw heads are governed largely by formulas has led the writer to formulate rules that govern those parts of machinery in which screws and nuts are used. Among the parts that may be standardized are: Finished washers suited to cap screws and to nuts; bosses on castings for setscrews; lugs on castings suited to roundhead screws, to square and hexagonal head screws, and to nuts or bolts; thickness of collars of collar screws; sizes of taper pins relative to the diameters of the shafts in which they are used, etc. Diagrams standardizing parts and pieces such as those enumerated save much time in the drafting room and relieve the draftsman of a large part of the detail that otherwise must be worked out anew in each recurring case.

Returning to the subject proper, it might be of profit to inquire into the ways of expressing by drawing, diagram or words the dimensions of screws and bolts. It is quite a common practice to overload a sketch or diagram with dimensions, and it is also of frequent occurrence that dimensions are given which are complements of the ones intended. This may be made clearer by an illustration or two. A sketch such as Figs. 1 or 2, with the dimensions L and B, indicates that the piece is wanted with the blank part of the body a specified length, whereas this is very unusual; and if the piece was made as called for, the working useful part of the thread would probably be too short. What is usually intended to be expressed are the dimensions T and L, or N and L. A sketch such as Fig. 3, with the length expressed as shown at Y, leads to confusion, as it is impossible to leave as much blank as the dimension B calls for if the lengths of useful thread are as called for by the dimensions T and N. Ordinarily what is desired is the length of the threads T and N, as shown at X, which, with the dimension L, is enough. If the blank part is to be of a specified length, the dimension should be written as shown at Z, stating also the length L.

At this point it might be well to state that a stud with one end chamfered is usually threaded large enough on that end to fit tightly in a tapped hole; and if it is desired that both ends are to be threaded to fit nuts, then both ends are made rounding and the lengths of thread for both ends are expressed as shown at N. Other points are brought out by Fig. 4. Though apparently very clear and exact, it does not mean just what it states. In the first place, the dimension 1⅛ inch should be explained by words under it such as "short diam.," as the intention is no doubt that the head is desired 1⅛ inch hexagon, and not 1⅛ inch across the corners. It is conventional to show three faces of a hexagon head, as the other view showing but two faces might be mistaken as showing a square head; while a square shown by a view of one only might easily be taken to represent a round head. The words "short diam." would remove all doubt, while the view shows the style of head. In the second place the drawing shows the thread running abruptly into the shoulder, a practical impossibility, and the dimensions would also lead one to think the nut should screw close to the shoulder. While the thread can be cut with a die of extremely short lead so that a nut could be screwed up to the shoulder, it would be difficult to make a very satisfactory job of it. To avoid any ambiguity it would have been better to have shown a neck in the screw under the shoulder, if the nut is to screw direct against it, or a short blank left under the shoulder if a washer is to be used under the nut.

Another matter not yet touched on, and one that pertains, or should pertain, to all specifications for screws (or other turned machine parts) is that of "fit." Some instruction such as tight, steam-tight, loose, snug, journal fit, tight wrench fit, finger fit, driving fit, etc., is necessary to make a specification complete. No two persons, of course, can or will interpret instructions such as the above in the same way, but the personal element is not so uncertain but that much good would result if the draftsman would give some attention to this matter in making up his sketches or lists. From trade experience, and from machine shop experience as well, it can be said that by being explicit in stating how the several parts of a machine (including screws and bolts) are to fit one another much trouble, time and money can be and is saved; perhaps more than can be saved in other ways requiring the same amount of thought and care.

Turning our attention again to Fig. 4, it is seen that changed as suggested, it clearly shows what is wanted, and, if put into words, the description would read:

Hexagon head shoulder screw.

Head 1⅛ inch hex. × 7-16 inch, nut finish on top.

Shoulder ⅞ × ¾ inch, journal fit in reamed hole.

Body 9-16 inch, 12 V threads, × ⅝-inch, oval additional, light wrench fit in C. H. nut. Necked under shoulder.

Other ambiguous statements are often made in specifications, more frequently in written descriptions, however, than in drawings. A little thought used at the right time will enable one to avoid them in either case. Attention is called to two common errors: (1) That of specifying "standard" without stating which standard, U. S. S. or V, is meant; and (2) that of not properly stating the angle of the head of a screw, such as the lower one in Fig. 1, or of the point of a conical pointed screw. To say the angle is 30, 40 or 60 degrees is indefinite unless qualified so as to plainly indicate whether the angle with the axis of the screw is meant, as shown at A, Fig. 1, or the included angle which equals $2A$. For instance "30 degree point" and "60 degree point" are usually taken to mean the same thing, although in interpreting these phrases one is assuming to mean the angle made by the sides of the point with the axis and the other the angle included by the sides of the point. Though 30 degrees (included angle) and 60 degrees with the axis (or 120 degrees included angle) are both uncommon, nevertheless a mistake is possible in assuming to interpret them either way.

* * *

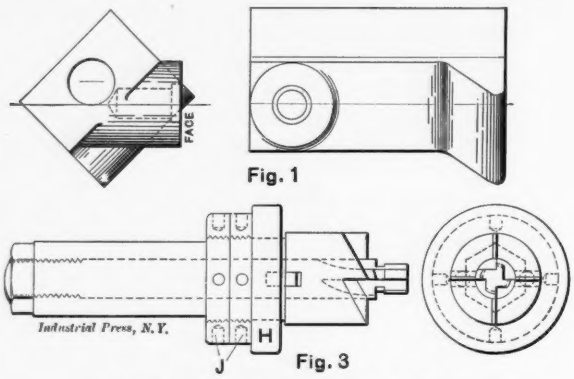
It would be theoretically possible to arrange a compressed-air motor so that it would drive the compressor that supplied it with air for its operation, and still have a surplus of power that could be used for other purposes. This could be accomplished by heating the air before it reached the motor, thus increasing the volume of the air and its capacity for doing work. The apparatus would then become a heat engine similar in principle to the Rider or Ericsson engines, power being derived from the fuel used in heating the air.

LETTERS UPON PRACTICAL SUBJECTS.

A DRILL JIG AND COUNTERBORE.

Editor MACHINERY:

The design of the jig and counterbore for machining the piece shown in Fig. 1 entailed not a little difficulty, and the tools with which it was finally accomplished may be of interest to anyone engaged in jig work. The casting to be drilled had one hole through its entire length while a second hole, which was afterward tapped, was drilled at an angle of 45 degrees to the side of the casting and with its center tangent



Piece to be Counterbored and the Counterbore.

to the diameter of the first hole. This hole was counterbored body size for a short depth and the boss in which it was located was faced to an exact distance from the first hole.

The jig in which the piece was held is shown in Fig. 2. For drilling the long hole the drill was guided by the bushing *A*, while the jig rested upon the legs *BB*. The work was held against a stop *C* by means of a knurled head screw *D* that was carried in a swinging arm *E* which fastened to the body of the jig and received the thrust of the drill. The body of the piece was fastened by means of a clamp *F* into a V-block formed in the jig casting. For drilling the second hole the slip bushing *G* was employed to guide the drill. This was then removed and the combination counterbore and facing tool, shown in Fig. 3, was run into the drilled hole until the loose collar *H* brought up against the face of the tight bushing *I*.

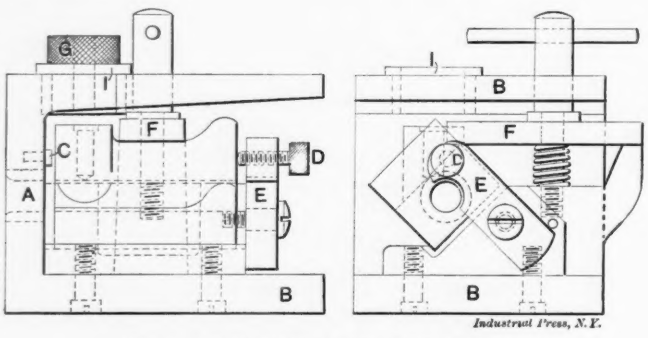


Fig. 2. Jig for Holding Piece shown in Fig. 1.

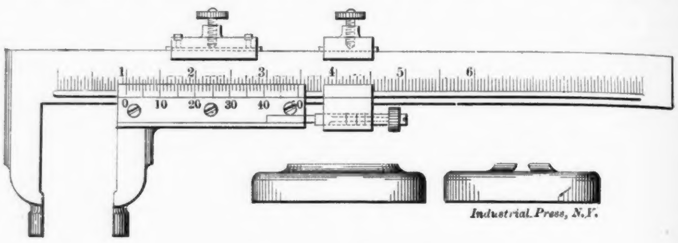
In this counterbore provision was made, by means of the lock nuts, *JJ*, for readjusting the depth of the cut after grinding the facing tool, and the body size of the counterbore had an independent adjustment which was locked by the nut at the upper end of the holder. After this operation the hole was tapped while still held in the jig, thus insuring that the tapping would be perfectly true with the face of the hole.

S. J. P.

A SPECIAL DESIGN OF SIX-INCH VERNIER.

Editor MACHINERY:

The accompanying sketch illustrates a 6-inch vernier, of the writer's design, which has several points of advantage over the usual form of vernier caliper and is suitable for use both as an outside and an inside caliper gage. The graduations on the beam and vernier plate are open to reading and no part of them is obstructed to view by the cross bar of the sliding head, as is the case in some calipers of this class. The reading on the bar gives the value for outside measurements, i. e ,.those made on the inside of the jaws; while the same size on the outside of the jaws is provided for, in the adjusting or follower head, by simply slackening the binding screw on the caliper head and moving it until it comes to a stop. To illustrate: the gage as shown is set to 1 inch outside diameter and if we desire to bore out a hole for the same exact size, or any amount under or over, as for drive or running fit, we first loosen the binding screw on the follower head and move it to the left until it comes to a stop against the caliper head, in which position we clamp it securely. Next loosen the binding screw on the caliper head and move it to the left until it is stopped by the interference of the knurled screw head against the follower. We then have the same size on the outside points that was indicated for the inside. Provision is made for adjustment when correction is necessary. This duplication, in the hands of an expert, equals that of any standard



Six-inch Vernier of Special Design.

inside and outside gages and has the additional advantage that any fractional measurement, in thousandths, is obtained over or under standard size.

This vernier may be used as a height gage by inserting the base in the dovetailed block shown in the cut, as the height of the block is such that it is 1 inch from the base of the block to the face of the caliper jaw. A scribing point may be clamped on the vernier head and lines scribed to exact height in thousandths. The groove at the base of the lines on the beam is for the purpose of cutting the graduations, as cutting out a chip disturbs the normal length of the bar less than the ordinary way of marking the lines.

F. W. CLOUGH.

TOOLS FOR MOLDING PORCELAIN.

Editor MACHINERY:

While there may be nothing novel or strange in the construction of the mold here described, yet the method and tools by which porcelain is molded may be new to many of the readers of MACHINERY. A surprising feature of this work is the allowance that must be given for the shrinkage of porcelain, it being no less than 9-64 inch per inch, and one company

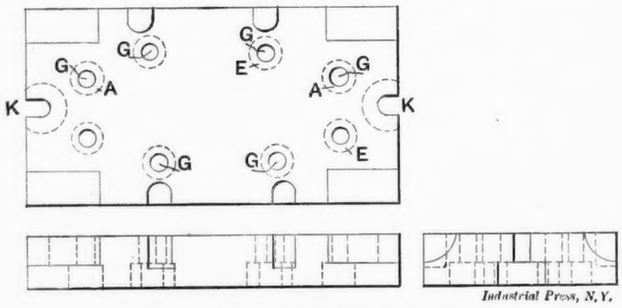


Fig. 1. One of the Molded Porcelains.

engaged in the manufacture of porcelain goods, recommends an allowance of 5-32 inch to each inch of measurement. In the mold here described some of the center distances required to be quite accurate and the writer found it most convenient to work to decimals and so used 1.14 as a constant for all of the measurements. Thus the center distance between the holes *AA*, Fig. 1, is to be 2⅜ inches and in the mold was made $1.14 \times 2.375 = 2.707$ inches.

The general principles of construction for a mold of this

kind will be seen by reference to Fig. 2, which is a detail of the mold used for making the piece shown in Fig. 1. The materials from which these molds are made are cast iron and steel. The molds wear away quite rapidly as the clay has an action like that of pumice stone against the wearing parts. The making of such molds requires considerable care and where sharp corners are needed the fits should be as good as can be obtained. Some draft is required where the bosses for making holes are long, but this will never be very great. The molds are fitted to presses and some pressure is required but not very much and this fact simplifies somewhat the problems of construction.

The views in Fig 2 show the mold with the top block *B* removed. It will be seen that it is essentially a rectangular

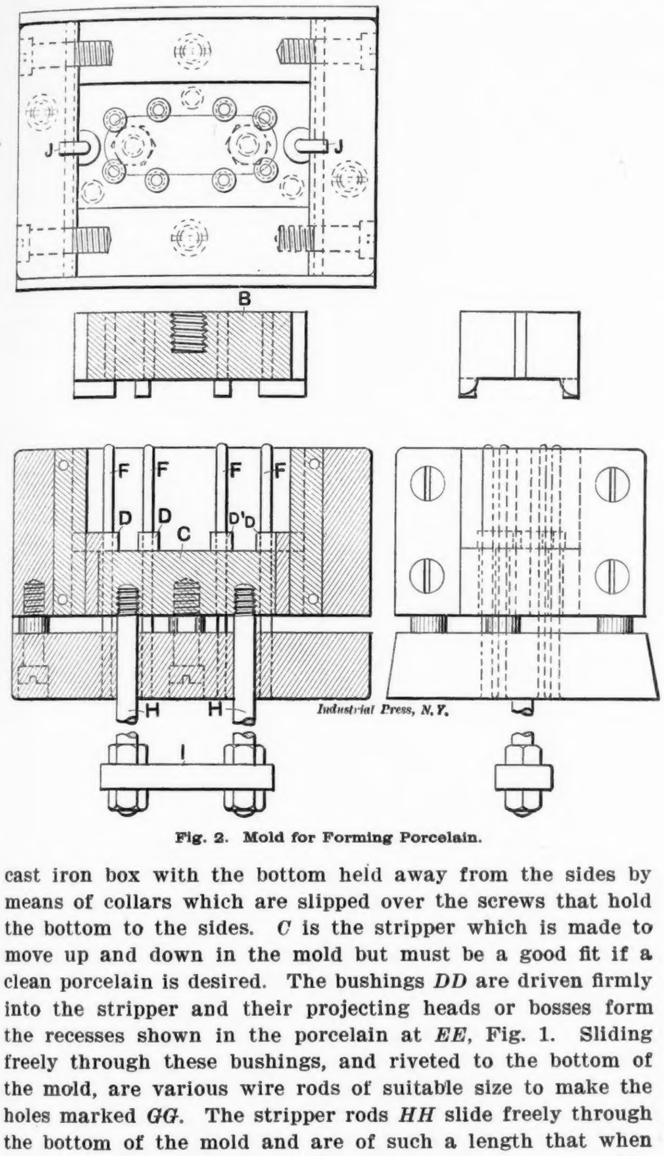


Fig. 2. Mold for Forming Porcelain.

cast iron box with the bottom held away from the sides by means of collars which are slipped over the screws that hold the bottom to the sides. *C* is the stripper which is made to move up and down in the mold but must be a good fit if a clean porcelain is desired. The bushings *DD* are driven firmly into the stripper and their projecting heads or bosses form the recesses shown in the porcelain at *EE*, Fig. 1. Sliding freely through these bushings, and riveted to the bottom of the mold, are various wire rods of suitable size to make the holes marked *GG*. The stripper rods *HH* slide freely through the bottom of the mold and are of such a length that when the nuts on the strap *I* touch the bottom, the top of the stripper will be slightly above the top of the mold. The pieces *JJ* are inserted in the ends of the mold and form the slots *KK* in the porcelain.

The block *B* is made to fit snugly into the mold and has holes which receive the rods *FF*. There are various projections on it which make the corresponding depressions in the porcelain. The thickness of the porcelain is determined by the distance to which the block is pushed into the mold.

J. R. Gordon.

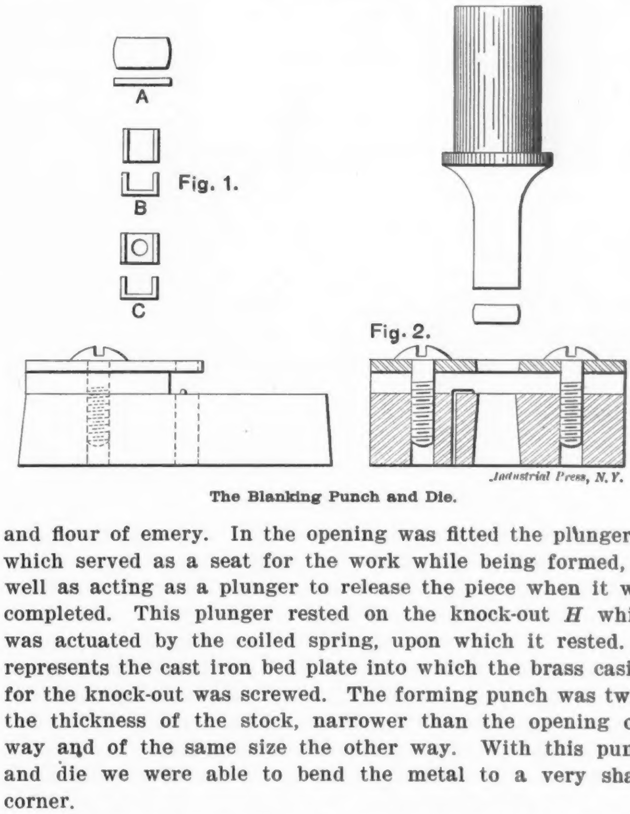
A JEWELRY PUNCH AND DIE JOB.

Editor Machinery:

Fig. 1 represents a piece of punch work that was made from gold stock and which required great accuracy in shaping as well as being bent at a very sharp corner as shown at *B*. Three operations were performed upon the piece as follows: First, cutting the blank as shown at *A*; second, bending as at *B*; and finally, punching the small hole in the bottom as at *C*. The metal was .020 inch thick and was lapped after being soldered onto a piece of jewelry. Several methods of bending were at first tried, but they proved unsatisfactory as too much trimming was required to obtain the necessary finish. The problem of bending was solved satisfactorily by the use of the punch and die here described.

The work was produced by the operations in the order above mentioned, but in order to obtain the proper size of the blank, the bending die was made first. This is shown in Fig. 3 and, as will be seen, is very simple in construction. The die proper, *D*, was planed on its face to receive the gage plates *E E*. A slot *F* was also planed to facilitate sliding in of the blanks, and another slot, running at right angles with *F*, served in conjunction with the tongues of *E E* to locate the blank in position for bending.

In order to obtain the square hole, which was of the exact outside dimensions of the blank, a hob punch was made in the milling machine and the opening broached through the die, starting from the back. In broaching a hole of this nature care must be taken not to remove too much metal, otherwise the surface will be rough and the corners not well defined. As the broach approaches the front of the die the amount of metal removed should decrease until the corners only are touched. After broaching, the die should be highly polished with a lapping stick and hardened, drawing the temper but slightly. It is then again polished brightly with a brass stick



The Blanking Punch and Die.

and flour of emery. In the opening was fitted the plunger *G* which served as a seat for the work while being formed, as well as acting as a plunger to release the piece when it was completed. This plunger rested on the knock-out *H* which was actuated by the coiled spring, upon which it rested. *I* represents the cast iron bed plate into which the brass casing for the knock-out was screwed. The forming punch was twice the thickness of the stock, narrower than the opening one way and of the same size the other way. With this punch and die we were able to bend the metal to a very sharp corner.

By the cut-and-try method, in connection with the bending die, it was a simple matter to determine the proper length of the blank, and the blanking punch and die were then made. The punch was simply turned down and milled to the proper width and with this the die was broached. The writer has always found it to be good practice to make the punch first in all cases where it can be machined and then with it broach out the die; this method of procedure invariably resulting in a saving of time. The blanking punch and die are shown in Fig. 2 and will be understood without further explanation.

The perforating die by which the last operation was performed is illustrated in Fig. 4. A stripper plate *K* was fastened onto the base of the die *J*, by screws and dowel pins, and had a projecting arm *L* through which a hole, the size of the perforating punch, was drilled in line with a corresponding hole in the center of the hardened steel die. The indexing dial was made of steel about 3-32 inch in thickness. The top and bottom were accurately faced and the edge knurled to facilitate turning. The stud *M* was inserted in

place with a thickness of paper under the head so that it would bind the disk tightly to the surface of the die. The die was then placed on the milling machine and the slot for the lever *N* was milled in the disk, using the slot in the hardened die as a guide. The die was then turned one-quarter of a revolution and the next slot milled in the disk; and so

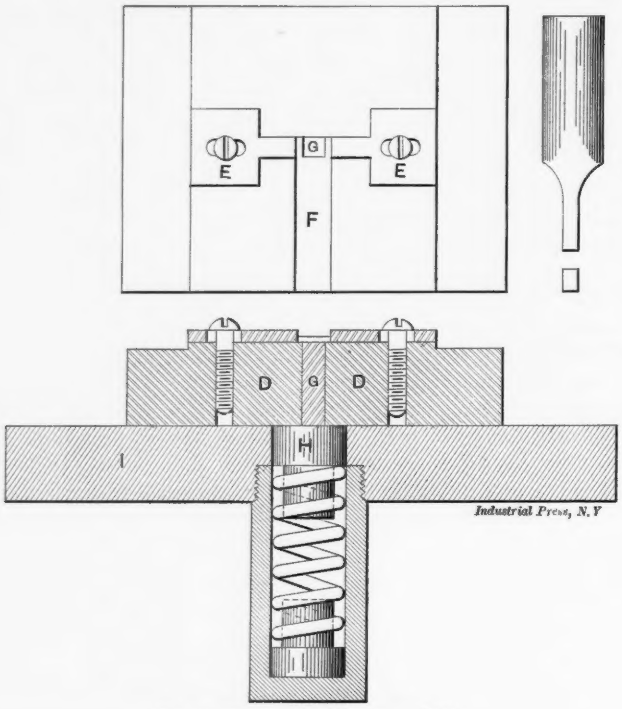


Fig. 3. The Bending Punch and Die.

on until all of the four had been cut, using the same cutter that was employed for making the original slot in the die. The index lever *N* is forged from a piece of tool steel and fits snugly the slot in the die, while the part engaging the disk, projects somewhat over the surface of the disk and tapers slightly to take up any possible wear. The lever is pivoted upon the pin *O* which ends about halfway through the hole *P*,

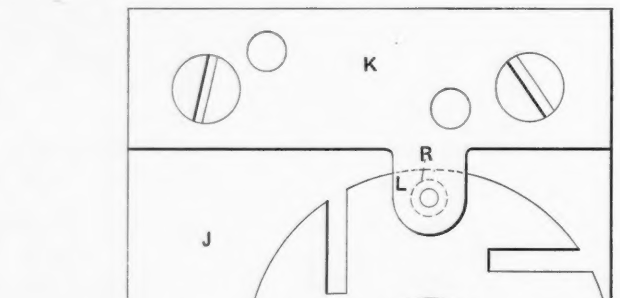


Fig. 4. Magazine for Die Piercing.

thus facilitating its removal should it be necessary. The most particular feature of this die was the location of the four holes, *R*, *R*, *R*, *R*, which served to hold the pieces while they were being perforated. Great care was observed to have the edges of the slots free from burrs, and the index lever was hardened before the holes were drilled. After the lever had been pressed into one of the slots, a hole corresponding in size to the perforation in the die was drilled through the disk from the back side. The disk was then turned to the next slot and so on, the four holes each being drilled while held in correct position relative to its respective slot. After drilling they were enlarged, by counterboring or by the use of several drills, to such a size that the punching might be slipped in without effort yet without leaving any play. The upper side should be slightly countersunk so that the pieces will locate themselves easily. The punch used with this die was of the usual form and is, therefore, not shown.

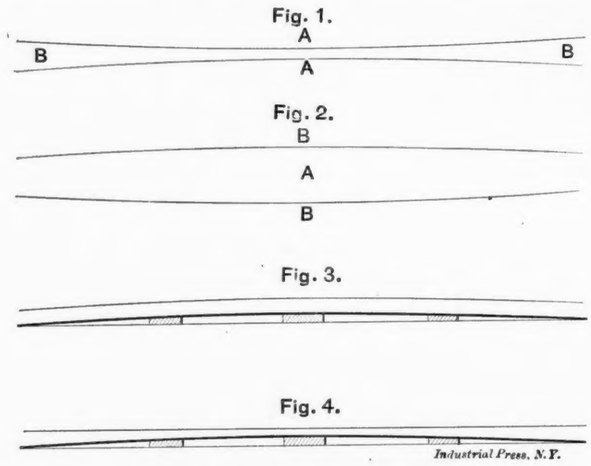
In operation, a punching was placed in one of the holes *R* and the disk moved around by hand until it was opposite and below the hole in the stripper plate. The left hand then allowed the index lever *N* to engage the respective slot in the disk, and the foot of the operator brought down the ram of the press, thus perforating the punching. Another punching was then placed in the hole next to that in use, the index lever disengaged, and the disk moved around a quarter of a turn so as to bring the new punching under the perforating punch. In doing this the punching that had been perforated remained in the disk and was moved around until it came over the hole *S*, in the die; then, as the punch descended, a pin fastened in the holder pushed it through the die and it fell into a box below. It will be seen that this arrangement saves a great deal of time, as it is unnecessary to take the punching from the die and it permits the operator to employ any lost time in placing punchings in the front part of the disk while those under the punch are being perforated.

New York City. FRANK GREINER.

PLANING CURVED SURFACES.

Editor MACHINERY:

By this title is meant the planing, not the milling of curved surfaces that are not circular in contour, the forming of which is known as radial planing. The matter in hand pertains to



Planing Concave and Convex Surfaces.

the formation of long thin pieces with perfectly smooth surfaces, convex or concave in the direction of their length on an ordinary, movable bed, planing machine, and without any special tools or attachments.

Suppose that the average connecting rod and coupling rod for locomotives has too little vertical stiffness, especially at high speeds, and too little sidewise flexibility. As, since the days of Matthew Baldwin and his "spherical crank pin" (which really was "barreled" in a spherical curve, to enable locomotives to turn a corner with grace and facility) about the only way of giving a main rod or a side rod any leeway laterally is to give the pin "shake" in the brasses; the laterally flexible rod may be one way out of the difficulty under which all roads labor—and which I may add used to be a specialty of the Baltimore & Ohio Ry. between Baltimore and Washington.

Not that lateral flexibility is the main desideratum, but vertical stiffness is, and that can only be got by widening, or thickening the rod. But even "fish bellying" the rod adds some to the weight, if the rod is of even thickness, and it is desirable to avoid that and even further lighten the rod.

Where the rod is parallel in width (i. e., not fish bellied) a good way is to mill or forge out the center so as to leave the piece of I-cross section.

As the metal along and near the neutral axis is of little or no use in giving vertical stiffness (although it is as good as any as regards laterally stiffening the beam-like member) this I-section is a capital good thing and would be very much better if forged instead of milled; but we have not got that far yet. To mill out all but a flange on each edge and leave a fish-bellied portion of less thickness than the rest (that is, to have an I-cross section of varying height and uniform thicknesses) is not yet a milling nor a planing possibility; and the flanges give lateral stiffness. Now if we will make the top view of the rod as in Fig. 1 and the side view as in Fig. 2, and ease off gradually between the stub ends of the rod proper, we will have an ideal rod.

The faces $A\,A$ may be planed or milled, for that matter, on a slab miller. The piece is strapped down at the ends and blocked up in the center, so that it comes to the bed as shown in Fig. 3. Then a planer cut is taken off the convex face, and the piece reversed so as to give another convex face, only the blocking must be higher than for the first operation. When through, the piece has two faces which are concave in the direction of their greatest length. The sketches are purposely exaggerated and simplified. To plane such a piece, thinner at the ends than in the center, strap it down in the center and block it up at the ends. ROBERT GRIMSHAW.

Hanover, Germany.

NEW CRANKPIN TURNING MACHINE.

Editor MACHINERY:

The photographs, Figs. 1 and 2, show a new crankpin turning machine which has recently been erected at the engine works of Messrs. Richard Pohle & Co., Ltd., Riga, Russia. It has been placed on the market by Emil Capitaine, Frankfort-on-Main, Germany, and was exhibited at the Dusseldorf Exhibition last year.

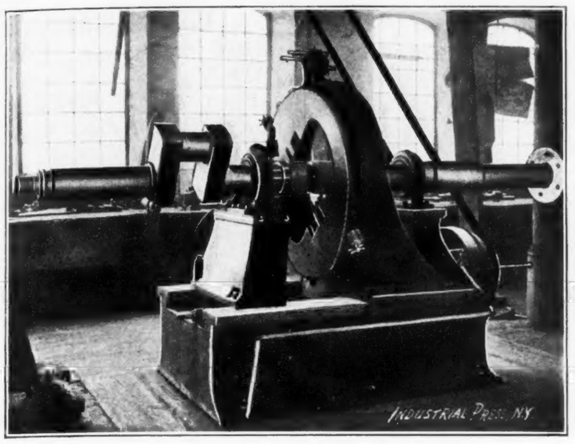


Fig. 1. Crankpin Turning Machine, Front View.

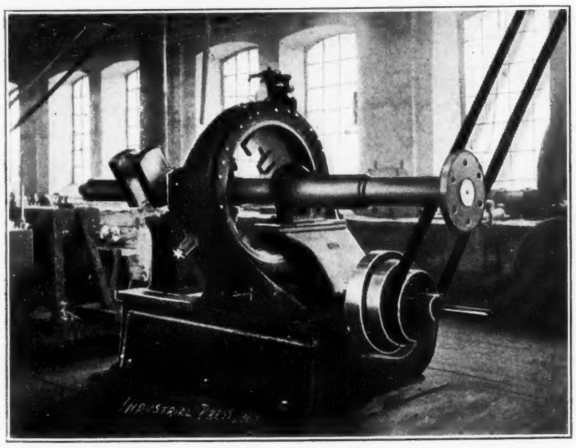


Fig. 2. Crankpin Turning Machine, Rear View.

It is well known that most crankpins are not cylindrical when turned in the usual manner in a common lathe, especially when the crankshafts are of large dimensions. Lately it was necessary to turn a number of crankshafts for some 350 horse power engines for the electric station at Vladuvistok, Siberia, and one of these machines was designed for the purpose, being capable of turning cranks up to 10 inches in diameter and 24-inch stroke. It consists of a bed in box form planed on the upper side, upon which are two brackets fitted with adjustable bearings and vernier scales. The first bracket has also a setscrew attachment for adjusting the crank arm. Between the brackets is the head frame which can be moved longitudinally along the bed. A ring revolves in the head and on the periphery of the ring is cut a 180-tooth gear. This ring is also connected with a disk made in two halves, each having guides, feedscrew attachment and one tool holder. Each half can be moved independently for turning the insides of the cranks. While turning the crankpin itself the whole head frame with ring and disk is moved automatically along the bed. The machine is belt-driven, having a three-cone pulley mounted on the head shaft, which can slide longitudinally in the axle boxes. Six different speeds are provided for, three by running with belt direct, and three by using the intermediate gears. A. WIND.

Riga, Russia.

FACE MILLING.

Editor MACHINERY:

The rapid and economical milling of large quantities of thin pieces is a problem that has been very satisfactorily solved at the U. S. Armory by the vertical milling system that is here described. The Pratt & Whitney Co. build a special drill press, illustrated in Fig. 1, that is admirably adapted to this class of work, but an ordinary drill press may be utilized by placing a jack under the table so as to prevent springing. The table and head must line up very accurately and be retained in that relation in order to obtain satisfactory results. The milling is performed with the face mill shown in Fig. 2, which fits the spindle of the drill. This mill is about 6 inches in diameter and has a pilot A which fits the center hole B in the milling fixture shown in Fig. 3. In making this mill the distance between the teeth must be less than the length of the pieces, otherwise they will be pulled out of the fixture when they are being operated upon.

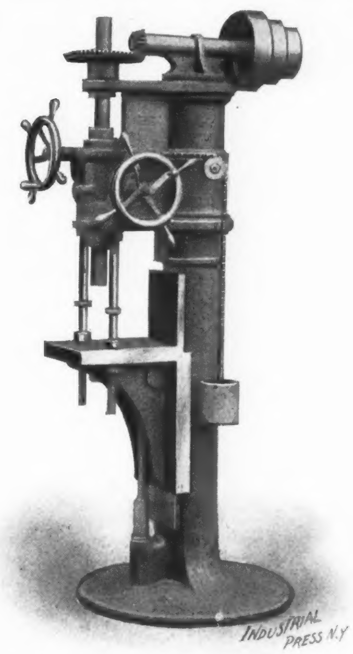
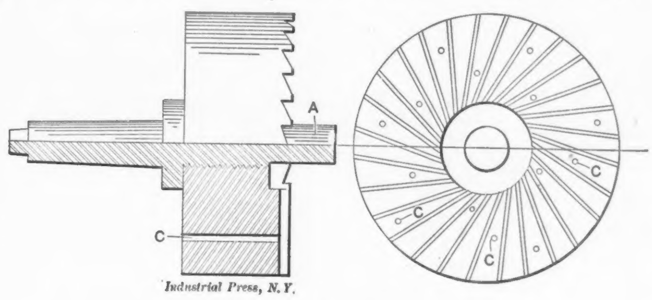


Fig. 1. Vertical Face Milling Machine.



Industrial Press, N. Y.

Fig. 2. Face Mill.

Oil is fed onto the work by pouring it on top of the mill, whence it runs down through the numerous holes CCC.

The milling fixture is made on the principle of a drill jig

with a leaf *D*, which is hinged at the pin *E*. The top of the base is ground true with the bottom of the legs. The base is a permanent fixture to which may be attached different leaves to suit the size and shape of the pieces to be milled. These leaves are planed on top and bottom and are screwed and doweled to the hinge, a special jig having been made for this purpose. The leaves have as many openings in them as the space will allow; with irregular pieces one row is usually all that can be used, but with small, regular pieces, as shown in the drawing, two or more rows may be employed. In making these openings, which must be a good fit for the pieces they are to hold, we first make a hardened templet having a hole of the required shape. This is clamped to the leaf and the holes are drilled out and then profiled, using a mill that has a shank of the same diameter as the cutter. This shank acts as a pilot pin and the templet guides the cutter so that it is possible to mill all but the sharp corners and very little hand work is required. The holes may all be located at the same distance from the center of the leaf by fastening the templet to a piece having a pin to fit the center hole *B*.

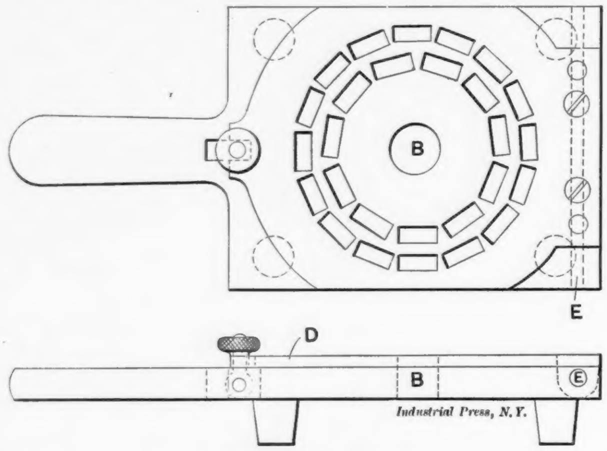


Fig. 3. Fixture for Face Milling.

To operate the fixture, fill the openings with the pieces to be milled and place the fixture under the mill, then feed the mill down onto the work. The pressure of the cutter keeps the work in place. When pieces are to be milled on both sides, after one side has been milled the leaf with the work in place is removed from the hinge, turned over and replaced and the second side is milled in the same manner as the first.

Springfield, Mass. C. H. WILCOX.

ON THE SUBJECT OF FRICTION.

Editor MACHINERY:

We so often read statements in advertising literature regarding the reduction or abolition of friction that some of our unmechanical friends might conclude that friction is our worst enemy, or at least a necessary evil. It is, however, more necessary than evil for, though the thought rarely enters our minds, it is nevertheless true that without friction every engine in the country would immediately go to pieces and, also, we should be unable to walk a single step. Now, like all phenomena in nature, friction is the more useful to mankind as he learns to make use of it in the proper manner for each purpose. Lack of ability or judgment in doing this has frequently produced failure. Friction is the worst enemy of the perpetual motion fiend, but it is the friend of the primitive savage who could not build his fires without it. If the reader has never yet attempted to produce a fire by rubbing together two pieces of wood he had best try the experiment, though, like one of Jules Verne's characters, he will doubtless become warmer than the wood.

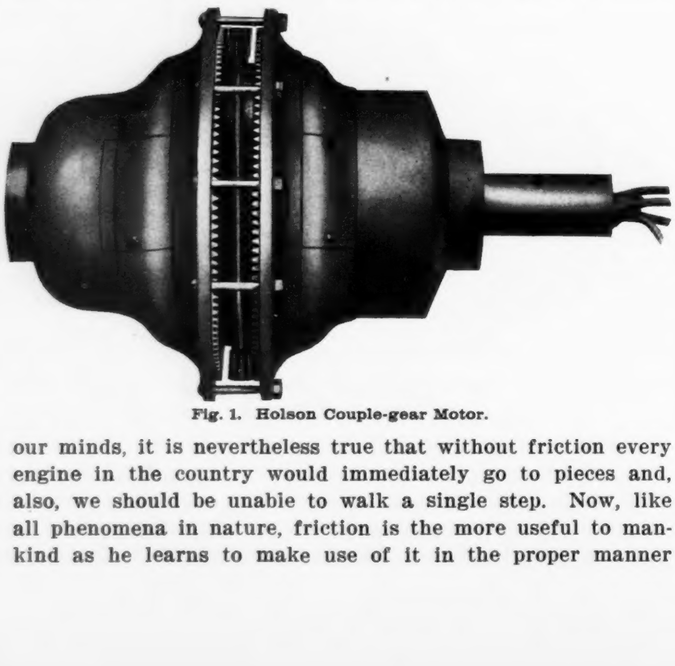


Fig. 1. Holson Couple-gear Motor.

There are some peculiarities about friction that should be better understood. One of these is the rule that the total amount of friction is independent of the area of contact. This is often interpreted literally or, rather, other factors arising from changes in the bearing area are ignored. Sometimes an increase in bearing area, by reducing the pressure per square inch, permits better lubrication with a resulting decrease in friction; whereas in other cases, as where adhesion or atmospheric pressure are active, an increase in bearing area may increase the total friction. Such results are not antagonistic to the general laws of friction but are the results of other elements entering in and modifying the result. The necessity of proportioning the amount of friction to the requirements has furnished ample opportunity for the exercise of inventive power and numberless are the arrangements and devices that are used to reduce friction on the one hand and to increase it on the other.

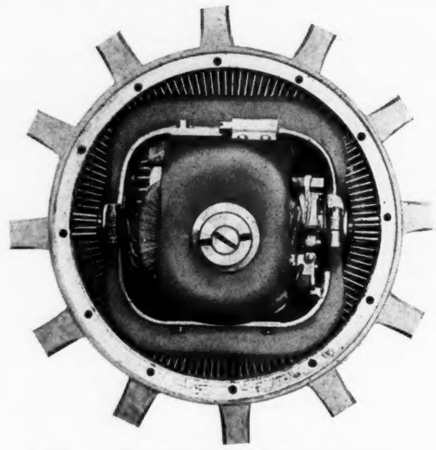


Fig. 2. End View with Casing removed.

For reducing friction we have ball and roller bearings, pivots, jeweled bearings and bearings floating in mercury or magnetically supported; while to increase friction substances having a high coefficient of friction upon each other are employed, or such a substance as sand, in railroading, is inserted between the surfaces. It is also in railroad work that "traction increasers" are used in which the friction is increased by placing additional weight upon the drivers. There is, where it can be practiced, no better way of reducing frictional losses than to do so by judicious design, not simply of the bearings themselves, but of the working parts in relation to each other.

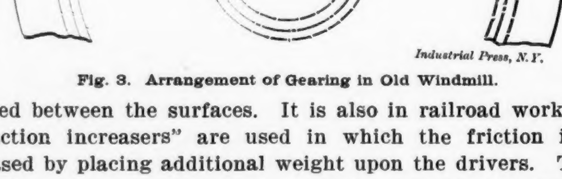


Fig. 3. Arrangement of Gearing in Old Windmill.

One of the best mechanical devices of this order that has come to the writer's notice is the Holson "couple-gear" motor, used on motor vehicles, and illustrated in Figs. 1 and 2. Fig. 1 shows each of the two pinions engaging one of the large bevel gears, while in Fig. 2 a view at right angles to

that in Fig. 1, the hub is shown with the outer half, containing one of the large bevel gears, removed to show both of the pinions. It will be seen that power is taken from both ends of the armature shaft, dividing the pressure due to driving between both bearings; and incidentally the driving member, or vehicle wheel in this case, is driven equally at two diametrically opposite points. A couple is thus produced by the driving pinions so that there is no friction in the bearing due to its being driven. An accurate test of this device shows it possesses a very high mechanical efficiency.

Quite another arrangement of gearing is illustrated in Fig. 3 and was used in a windmill. In the drawing, *S* is the wheel shaft carrying the pinion *A* which drives the internal crank gear *C*, through the pinion *B*, with a reduction of about 4 to 1. At the first glance there may not seem to be anything unusually unmechanical in the arrangement as here shown but when the writer was asked to examine this windmill, on the farm where it was in use, the proportions did not appeal to him very strongly. The design was such that pinion *B* was quite small and the stud *P* upon which it ran was also small and short. Besides this the manner in which the gear transmitted its power placed its bearing under twice as much pressure as that on its teeth so that, roughly figured, the pressure on the bearing was found to be so great that proper lubrication was impossible and the mill was soon condemned for that reason.

This subject of reducing friction by arrangement of moving parts as well as by good design of the bearing is far too broad to be given full discussion in the limits of a single article, but the two devices here shown, one a success and the other a failure, serve to illustrate the principle.

Grand Rapids, Mich. CORNEIL RIDDERHOF.

A SPECIAL CHUCKING FIXTURE.

Editor MACHINERY:

Not long ago while visiting a manufacturing and jobbing shop, the writer saw the chuck illustrated in Figs. 1, 2 and 3, which contains some points of interest that might be adapted to the rapid production of any work of a character similar to the pieces for which this chuck was designed. The casting for holding which this chuck was made was, as will be seen, of rather unusual shape. It formed a triple cylinder for a high-speed automobile engine which was being manufactured in the shop. It had three cylinders, *BBB*, which were required to be bored out and reamed to size at *C*, turned on the outside at *E*, and counterbored and tapped for plugs at *D*. The portion indicated by the letter *A* was the hub. The centers of all three cylinders had to be on the same plane and spaced so as to form exactly the same angle with each other.

The construction and use of the chuck will be seen by reference to the three views shown in the illustration. *G* is a faceplate, turned and finished to screw onto the lathe spindle and channeled down the face to allow of locating the angle plate *H* which is fastened to it by the cap screws *KKK*. The hub of the casting was first held in another chuck and bored out on the inside and finished on the outside to gages. This preliminary work formed the basis for the accurate accomplishment of all of the succeeding operations. The work was then located centrally on a boss *F*, formed upon the bracket *H*, so that the three cylinders would come approximately central. For clamping the three straps *NNN* were used; while the indexing was accomplished by plug *K*, Fig. 1, whose locating part was hardened and ground to fit the finished bore of the cylinder and also the reamed hole in the lug *J*.

When using the chuck, a casting was first clamped somewhat loosely upon the angle plate *H*, being located centrally by the stud *F* which projected upward about ¼ inch. A plug, which for a distance along its length fitted the reamed hole in the lug *J* and for the rest of its length fitted loosely in the cored holes in the cylinders, was inserted, through the lug, into one of the cylinders. The clamps were then tightened and the machining proceeded. First the outside of the cylinder was

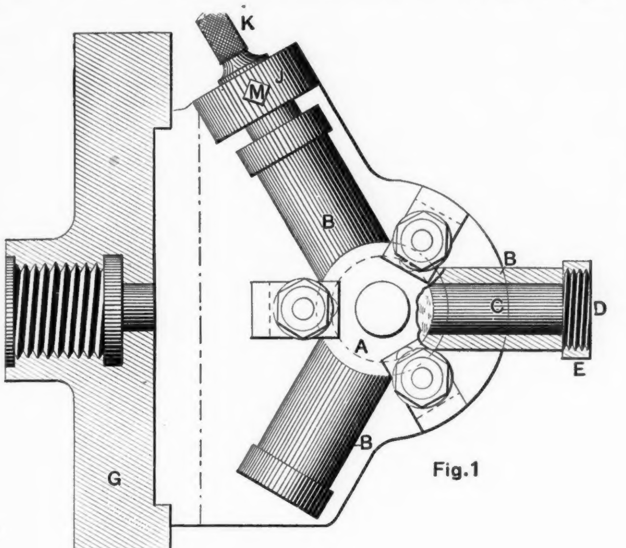


Fig.1

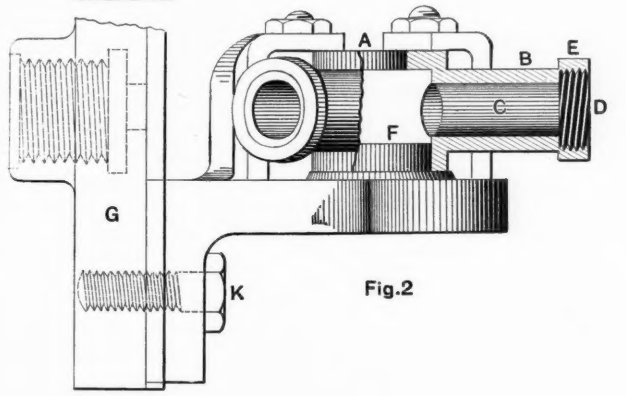


Fig.2

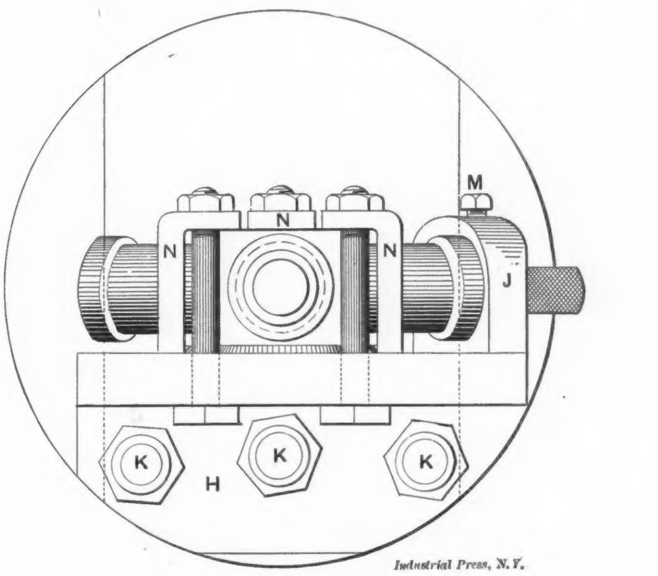


Fig.3

Fixture for Chucking Gasoline Engine Cylinders.

turned at *EE* and finished to gage, after which the steady rest was brought up and adjusted so that the finished portion ran true in it. This was followed by the boring and reaming which were done by first using a bar with an inserted cutter, then a shell-rose reamer, and finally a one-bladed reamer for finishing. After reaming the counterboring and tapping were done. Now the clamps were loosened and slid back, the work removed from the angle plate—the temporary plug having, of course, first been removed—and the casting relocated with the finished cylinder in line with the lug *J*. The plug *K* was inserted, through the lug, into this cylinder which it fitted perfectly. The setscrew *M* was tightened, thereby holding the plug securely in place, after which the clamps were secured and the second cylinder was bored, reamed and tapped as had been done with the first. After this the same method of procedure was followed for finishing the third, or remaining cylinder.

TUBAL CAIN.

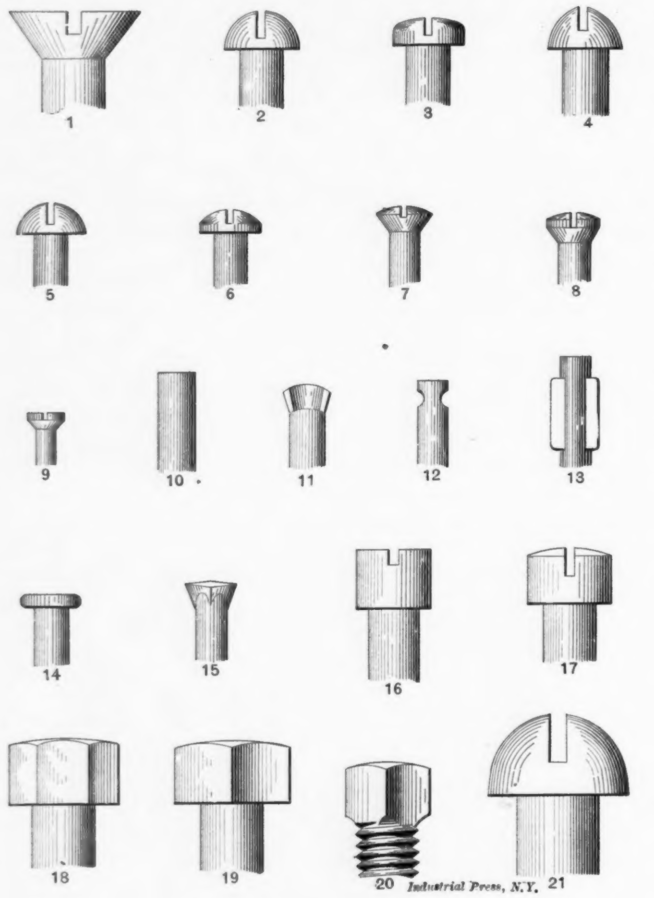
SCREW HEADS.

In the division of screws into classes the head forms an important part, and the name of the head is in most instances the method of distinguishing between the different classes of the same kind, as *round head* wood screws or *flat head* machine screws. The most common kinds of heads are easily learned, but even these are often a source of confusion to the young man beginning the business, while the styles of head not commonly seen in the hardware stock are a mystery to all those who have not had especial reason to learn them. The following brief description of each may help to fix the differences in the minds of those not already acquainted with the different styles.

1. Flat or countersunk head, used on all flat-head wood and machine screws, and on flat-head stove bolts. The top of the head is flush with the surface when applied.

2. Regular round head, used on round head wood screws and stove bolts and on machine screws. The head rests upon the surface of the object to which it is applied.

3. Regular round head used on machine screws larger than 5-16 inch diameter. This also is above the surface when applied.



Forms of Screw Heads.

4. Regular round head used on piano screws only. This differs from the round head used on wood and machine screws in the fact that it is higher.

5. A new round head used on piano screws only. This head has a larger base than the ordinary round head to give it a greater binding surface.

6. Fillister head used on piano screws. This head has also a large base to hold firmly to the surface upon which it rests. This screw is used in the piano action.

7. Regular oval head used on wood and machine screws. In application the edge of the head is flush with the surface, the slightly oval top rising above it, to give a better finish.

8. Oval head improved. Applied in the same manner as No. 7 and having the effect of giving a heavier or stockier head of the same diameter and surface contour as the regular oval. Used largely by gunmakers in attaching the plates to the locks of guns.

9. Head used on butt plate wood screws and damper block piano screws.

10. Headless, made with either wood or machine screw thread. These are used in castings where they are set into the piece cast with the screw protruding. Customers also buy them in this way and fashion the head into any special shape desired. Often furnished with heads slotted, and in use driven with top below the surface.

11. Pinched head used in castings with either wood or machine screw thread. The shape of the head keeps the screw from turning in its place.

12. Grooved head used in castings with either wood or machine screw thread. The groove is formed by pinching the rod and holds the screw fast in the casting.

13. Winged head, either wood or machine screw. When this is used a hole is first bored into the wood to receive the head and it is then driven to place, with the screw protruding, as in base knobs. The hole is the same diameter as the body of the screw. The wings keep the screw from turning.

14. Round bung head, used with wood or machine screw thread. Screws with this head are used in various ways. Many of them are used in the balls of curtain pole fixtures, being soldered into the ball.

15. Square bung head, used with wood or machine screw thread, in castings.

16. Flat fillister head, used with machine and cap screws. Used in machinery, usually with the head set in flush with the surface, in places where one part of the machine slides upon or passes over another.

17. Oval fillister head used on machine and cap screws. This is often countersunk the same as the flat fillister head, leaving the round above the surface for the finish, but is also used with the entire head above the surface.

18. Hexagon head used upon cap screws and machine bolts, and turned with wrench.

19. Square head used upon cap screws and machine bolts, and turned with wrench.

20. Square head used on set screws. The head of a set screw is always of the same diameter as the body of the screw and the thread is cut to the head. These are made with a variety of points, such as round, flat, cup, cone, hanger pivot, flat pivot, round pivot, etc., all shown in the Screw Department catalogue.

21. Button head used upon cap screws. It is slightly higher than the regular round head used upon wood and machine screws.—*From Circular of P. and F. Corbin Co.*

* * *

ITEMS OF MECHANICAL INTEREST.

PUNCHING SEAMLESS TUBES—PORTABLE BORING MACHINE—SENSITIVE FEED DEVICE FOR DRILL —NOVEL ROTARY PUMP.

The recent improvements on the line of the London, Brighton & South Coast Railway in England comprise a bridge over the tracks of the London & Southwestern Railway which is remarkable for having one span in which the girders are 150 feet long from the centers of the column supports. The construction is of the single triangulation or N type with the upper boom curved.

A rule recently published in the *Scientific American* for finding the power of windmills, is as follows: Find the square area of the slats in the wheel in the plane of revolution. This may be assumed to be the same as that of a circle of the diameter of the wheel. Multiply the area by the cube of the velocity of the wind in feet per second. The product divided by 4,000,000 gives the horse power. Example: What is the horse power of a wheel 12 feet in diameter in a wind blowing 15 miles per hour? Area of the wheel equals $12^2 \times .7854 = 113$ square feet. 15 miles per hour is a velocity of 22 feet per second. $22^3 = 10648$ which multiplied by 113 and the product divided by 4,000,000 gives 0.3 horse power.

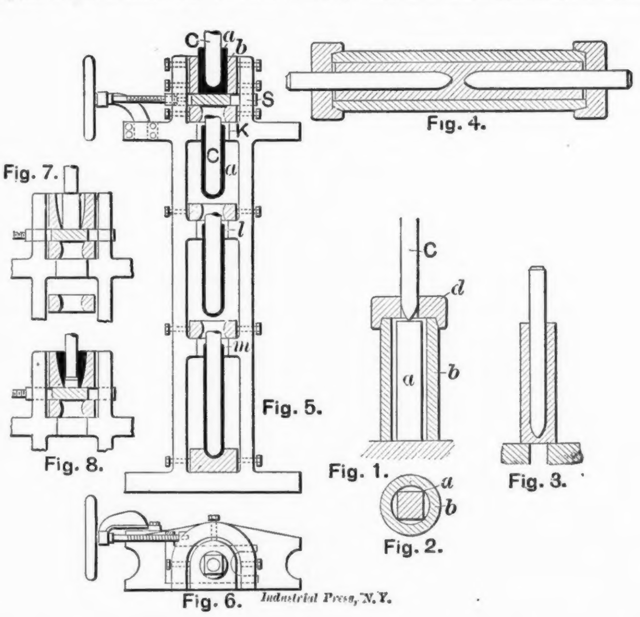
A factory has been started at Hoslund, Norway, by C. G. P. DeLaval, of cream separator and steam turbine fame, to exploit his electric process for the extraction of zinc from the ore. The process consists essentially of an improved electric furnace which is not only adapted to the reduction of

zinc ores, but many other ores. The gist of the improvement consists of means for the continuous introduction of the ore to the furnace and means for preventing the finely-crushed material being scattered about by the gases generated by the intense heat. The difficulty in separating the volatile gases from the pulverized ore that is thrown about by the violent chemical processes incident to the great heat has been heretofore one of the chief obstacles to the use of the electric arc in the reduction of certain ores.

The property of a vacuum by which a negative condition enables the atmospheric pressure to produce a positive result was formerly a great mystery to mankind. The Greek philosopher, Aristotle, the pupil of Plato and the teacher of Alexander the Great, explained the rising of water in a pump and similar manifestations of atmospheric pressure "because Nature abhors a vacuum," and it was nearly two thousand years until the time of Galileo—by whom the phenomenon was logically demonstrated as being caused by the weight of the air. And it would be not beyond belief to find that the true meaning of Galileo's discovery had not yet percolated through the skulls of all present-day gentlemen who make some pretensions to knowledge of physics and kindred sciences. But, nevertheless, we can scarcely repress a smile, strive as we may, at the naive remark of a prominent member of New York City's fire department, who, when asked at the trial of Edward Croker (late chief of the fire department), to define a vacuum, is alleged to have said "a vacuum is an inch of nothing."

PUNCHING OUT SEAMLESS TUBES.

Apropos of the interest that is now being manifested in the United States in the manufacture of hollow axles and the method of producing them, a description of the method employed in the town of Montbar for making seamless tubes of circular section by punching them from square bars may be in order. The process is one of punching and die forging simultaneously. To get a tube of circular cross section, there is introduced into the mold a matrix, or die, *b* (Figs. 1 and 2), a square bar *a*, heated to cherry red, and of such dimensions that



its diagonal equals the diameter of the cylindrical die, this having the object and result of exactly centering the bar which is to be expanded in the punching process. The cap *d* serves as a guide to the punch *C*, which latter has the diameter of the required bore of the tube. The calculation of the minimum quantity of metal necessary to give a tube of a given diameter is very simple.

Thus, for a tube of one inch external diameter the punch must have a diameter of 0.603 inch for the metal just to fill the mold. This gives walls of 0.1985 with thickness. Where thicker walls are desired, for a given external diameter, the bar must evidently have its corners truncated or its sides rounding so that there will be less space between the bar and the mold, and the area of the punch must just equal this space. For a thinner tube, the sides of the bar may be concave. The punch does not go all the way through; the plug left at the bottom (see Figs. 3 and 4) must be drifted out or otherwise removed. For long tubes, two punches are employed, working in opposite directions as in Fig. 4.

The friction of the bar on the die is so great that the pressure of the punch on the bar is comparatively low. Figs. 5 to 8 show in principle but not in detail a machine for making tubes from an ingot *a* of any desired cross section. This is first stamped by the punch *C* in a die *b* closed by a sliding piece *S*, which can be used to close the bottom of the die, by means of a screw and handwheel. The preliminary punching having been effected, the piece *S* is withdrawn and the punch continues its course, driving the metal through a series of dies *X*, *l*, and *m*. Another way is to use a punch-shaped matrix of special form, shown in Figs. 7 and 8.

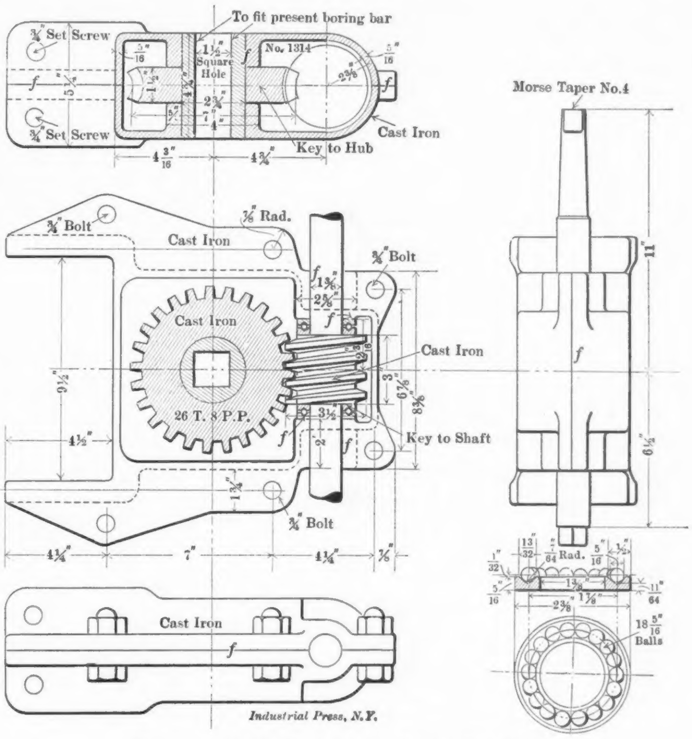


Fig. 9. Portable Worm-driven Boring Machine.

The precision attained by this work is remarkable and the polish surprising. Shrapnel are made, with a thickness of wall of only 2 millimeters or 0.08 inch "scant." For very long tubes the short tubes resulting from the punching are drawn further in dies, without being allowed to get cold; they will stand three redrawings without reheating. When the wall is not more than 3½ millimeters or 0.14 inch thick, cold drawing on a mandrel suffices. It is not necessary to heat beyond a cherry red.

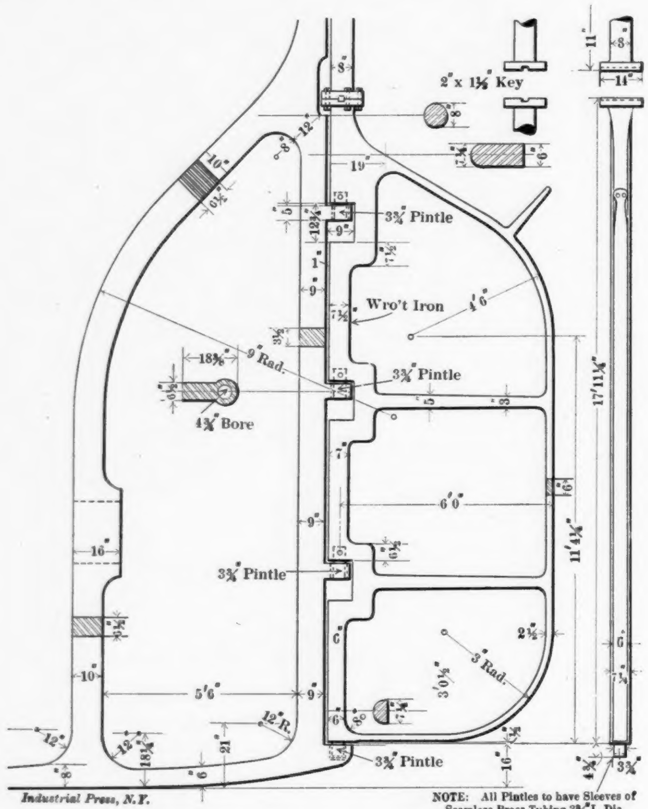
In the first experiments made in Germany, the hydraulic plungers had a diameter of 0.50 meter and a stroke of 1.10 meter or 20 inches diameter, 44 inches stroke, and with 90 atmospheres pressure, tubes were produced up to 60 millimeters or 2.364 inches diameter. At present the same press works at 180 tons pressure and produces tubes up to 240 millimeters or 9.46 inches diameter. In Dusseldorf there are several such presses at work, making gun barrels, etc., at one quick pressure. The limit of exactitude of diameter or of thickness is one-tenth of a millimeter or four thousandths of an inch.

In Dusseldorf there are made by this process boiler tubes, steam pipe, and all sorts of tubes, hollow axles, shells for cannon, cannon barrels, and reservoirs for compressed gases, up to a pressure of 250 atmospheres. The pressure exerted on the material in manufacture condenses it and increases its tensile strength; at 500 atmospheres the reservoirs tear but do not burst. The steel employed must have a tensile strength of from 41,000 pounds to 129,000 pounds per square inch and a coefficient of elongation of 15 to 30 per cent., both of which are increased by the process of manufacture.

Hanover, Germany. *Robert Grimshaw.*

PORTABLE WORM-DRIVEN BORING MACHINE.

The portable worm-driven boring machine shown in Fig. 9 is one that was made some two years ago by the Chicago Shipbuilding Company for boring the holes in stern-posts for rudder pintle bearings. It consists of a hollow cast-iron frame made in two parts and tightly inclosing a worm and cast-iron wormwheel of 26 teeth, having a square hole through the hub for the reception of the square boring bar or the head of a reamer. The frame is made with two opposing jaws having setscrews by which the device can be securely clamped to the rudder post or other work when in use. The worm is also made of cast iron, and its thrust is taken by ball bearings. The feature of ball bearings is an essential one as it not only greatly increases the mechanical efficiency, but reduces the causes for heating. The motive power is connected by means of a Morse No. 4 taper socket fitting the end of the worm shaft. Since the worm is single thread and the number of teeth in the wormwheel is 26, it is obvious that the leverage of the driving motor is greatly multiplied, making it possible to use a motor of comparatively weak torque to drive a heavy cut.



NOTE: All Pintles to have Sleeves of Seamless Brass Tubing 3¾" I. Dia. x ⅛" thick. Bearings to have ¼" of Babbitt outside of Brass Sleeve.

Fig. 10. Stern Post and Rudder for which Portable Boring Machine was used.

The particular job for which the rig was designed, is shown in Fig. 10, being the working drawing of a stern-post and rudder for (four) vessels built by the company. The pintle holes in the stern-post are, in this case, 4¾ inches diameter and 5¼ inches deep while the pintles are only 3¾ inches diameter. The difference in diameter is made up by a brass sleeve ¼ inch thick with which each pintle is bushed, and a babbitt lining ¼ inch thick in the stern-post. The device is also used for boring the sockets for the pintles, in the rudders. It is, of course, applicable to a large range of other work in shipyards and general manufacturing plants where portable apparatus is used.

INGENIOUS SENSITIVE FEED DEVICE.

The feed device of the hand drilling machine shown in Fig. 11, is a somewhat ingenious English adaption of the steam engine centrifugal governor principle, the drill spindle being moved downward through a limited distance by the outward tendency of the balls, the same as the valve stem of a fly-ball governor. In effect it forms a sensitive feed device in which the pressure developed between the point of the drill and the work depends on the speed with which the machine is driven. The balls also act as a flywheel to keep the motion steady. When the hole is drilled and the machine is stopped the drill automatically lifts out of the hole as the balls drop. One obvious disadvantage of this principle is that the pressure of the feed is in inverse ratio to the size of the drill, provided,

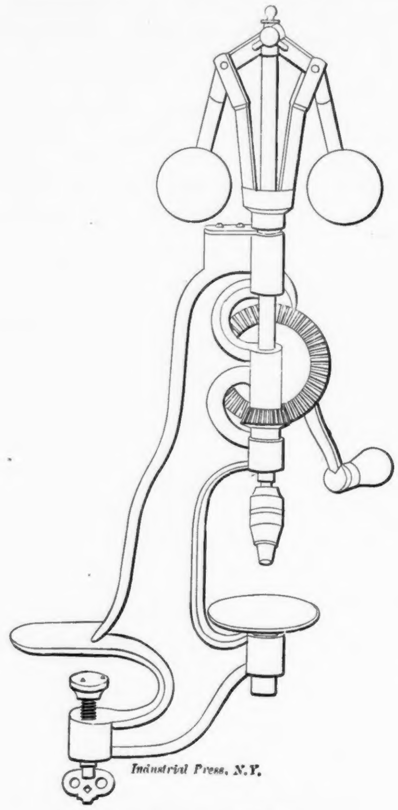


Fig. 11. Sensitive Feed Device.

of course, each size of drill is driven at its proper cutting speed. For small hand drilling machines, however, in which the range of drill sizes is narrow, this objection is of little weight.

NOVEL PUMP.

The *Horseless Age* recently described a novel, so-called rotary pump, invented by A. Butin and manufactured by the well-known automobile concern, De Dion & Bouton of Puteaux, France, presumably for automobile purposes. Although referred to as a rotary pump, it is really an oscillating piston pump, the piston being semi-circular and oscillating in a hemispherical case. But, because of the peculiarity of construction which makes the plane of oscillation rotate with piston,

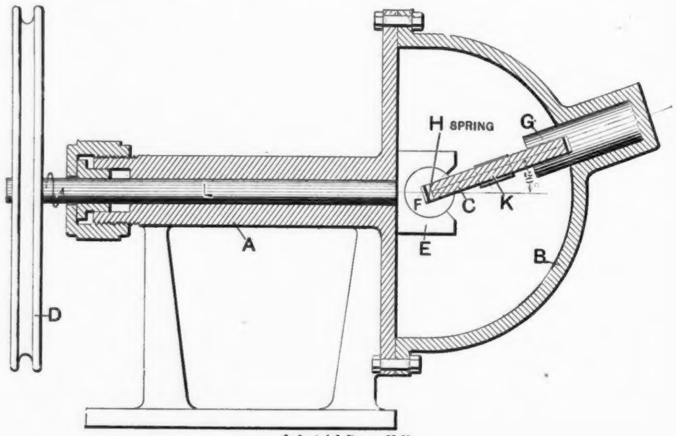


Fig. 12. Novel Form of Rotary Pump.

it is possible to dispense with inlet and discharge valves. This is because one port acts constantly as a suction port and the same applies, of course, to the discharge port, as will be seen further on. The case *B*, Fig. 12, is secured to the end of the base casting *A* so as to form a water-tight joint. The shaft *L* transmits motion to the oscillating piston *C* through the medium of the crosshead *E*. This piece is bored throughout

its length to receive the small rocking cylinder F, and it is slotted along one side for the piston C. The cylinder F is grooved to receive the piston and a flat spring H is laid in the groove to keep the piston constantly against the inner wall of the case. A bearing for a short shaft G is bored in the case at an angle of 20 degrees with that of the shaft L. The inner end of the shaft G is slotted to receive the outer edge of the piston C. Two ports for suction and discharge are provided in the case, oppositely situated. One of the ports is shown at K directly beneath the piston C. In this position which is the maximum angle made with the driving shaft, both ports are closed by the edge of the piston.

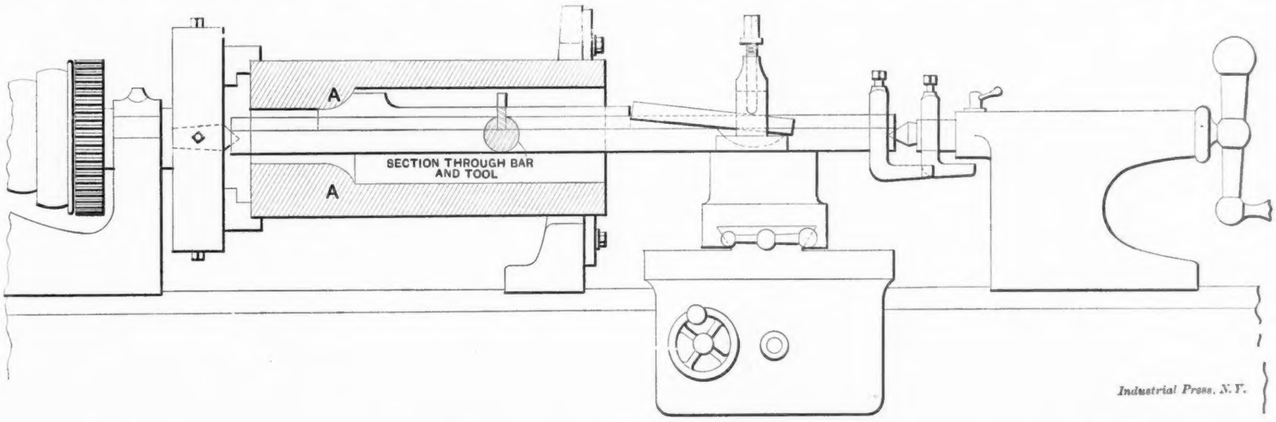
The operation is as follows: the crosshead E and disk C divide the chamber formed by the casing B into two compartments, which are constantly varying in volume as the disk rotates, one decreasing in volume while the other increases. In the position the disk occupies in the drawing the upper compartment has a minimum volume and the lower a maximum volume, and as the disk continues to rotate, the compartment which is now the upper constantly increases in volume for a half a revolution of the disk. During the entire time this compartment is in communication with the suction port and water is drawn into this compartment equal to the increase in volume. When the compartment has reached its maximum volume it is closed to the suction port and opened to the discharge port by the motion of the disk. During the next half revolution of the disk the volume of the compartment considered constantly decreases, and, as the compartment is open to the discharge port during this half revolution, the water is forced out through this port.

* * *

CONTRIBUTED NOTES AND SHOP KINKS.

BORING A ROUND SHOULDER.

G. Trueger sends us a description of a job that he recently had to do, and the method by which it was done may serve as a suggestion for accomplishing a number of jobs of a similar nature which are often encountered. On the inside of a cylinder it was necessary to round a shoulder that was about 12 inches deep, as shown at A in the sketch. It was found that this could not be done with an ordinary tool held in the toolpost, owing to the spring and chatter of the tool, so the arrangement illustrated was devised. The casting was first bored and reamed in the usual manner being held in a lathe chuck with the outer end supported in the center rest. A $1\frac{1}{2}$-inch shaft was centered and a keyway, 5-16 inches wide and $\frac{5}{8}$ inches deep, was cut its entire length. This shaft was placed on the lathe centers and prevented from turning by using two dogs on the tailstock end. The cutter consisted of a piece of tool steel of suitable width to just slide freely in the slot of the bar and shaped on the front end to the required radius of the corner. It was of sufficient length to extend out in front of the hole and was fed up to the work by a bar held in the toolpost. The results of this boring were very satisfactory, the corners being round and very smooth.



A CONVENIENT SCRATCH GAGE.

M. H. B. sends the accompanying sketch of a scratch gage which, he says, is better adapted to all kinds of work, around circles, close to corners and shoulders, etc., than any other that he has seen. The head is a steel block with a V-groove on one side and holes through it, both lengthwise and crosswise, to receive the bar which is secured in either position by the gib and screw as shown in the figures. By reversing the bar, as in Fig. 2, the tool is made capable of its closest

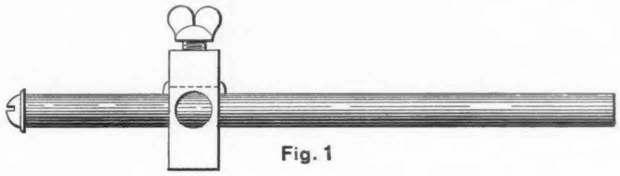


Fig. 1

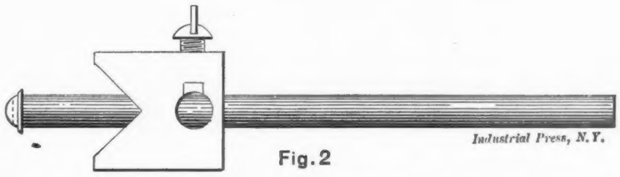


Fig. 2

work into corners, etc. The scratch point is a square, flat piece of hardened steel beveled off on the outside corners and fastened by a button head screw passing through its center and binding it to the end of the rod.

SCRIBING A CENTER LINE ON WORK HELD IN THE INDEX CENTERS.

It is often required to scribe a center line on gear blanks, or similar work, held in the index head and the following method, contributed by G. G. P., will be found an easy and accurate way of doing this. Set the scriber on the surface gage as near as possible to the height of the center of the index head and scribe a short, fine line on the face of the blank. Then index half way around and make another line on the same side of the blank as the first and if the scriber was set central with the head the two lines will coincide, forming a single line. If the scriber was not set central the two lines will be a short distance apart and equi-distant above and below the center so that, by setting the scriber midway between these two lines and trying again as before, a center line can be quickly and accurately made. Now by indexing one-quarter of the way around this center line will be brought exactly on top and central so that the center line on the cutter can be set to it.

If the cutter has no center line, make two lines which shall be equi-distant each side of the center, by setting the scriber a little above or below the center of the head and making one line, then indexing around and making another line on the same side of the work as the first. Now if we index one-quarter of the way around it will bring these two lines on top and in central position so that the cutter can be set midway between them. When the scriber has once been set at the exact height of the center of the head it is well to scribe a line on some part of the head, which will aid in setting at any future time.

* * *

A writer in the *Electrical Review* gives a formula for a solder to be used as a protection to telephone apparatus, which melts at a temperature of 160 degrees. It consists of lead, 2 parts; tin, 4 parts; bismuth, 7 parts; and cadmium, 2 parts.

HOW AND WHY.

A DEPARTMENT INTENDED TO CONTAIN CORRECT ANSWERS TO PRACTICAL QUESTIONS OF GENERAL INTEREST.

Give all details and name and address. The latter are for our own convenience and will not be published.

1. A. S. C.—Is there any less expensive metal or alloy used as a substitute for platinum for electrical purposes?

A.—There is a compound, imported from Europe, called "latinum" that is largely employed by telephone makers in the place of platinum for contact points. The price is $13.00 per ounce, and as it is but one-half as heavy as platinum, the actual cost is about one-third as great.

Another substitute for platinum, used for an entirely different purpose, is "platinite," which is an alloy of nickel and steel. It is possible to make this compound in such proportions that its coefficient of expansion is equal to that of platinum. For this reason it can be used in the place of platinum in the manufacture of electric lamps. It has been the custom to use short sections of platinum wire in incandescent lamps because, up to a few months ago, it was the only metal known having the same coefficient of expansion as glass. As stated, "platinite" is now used to some extent for the same purpose.

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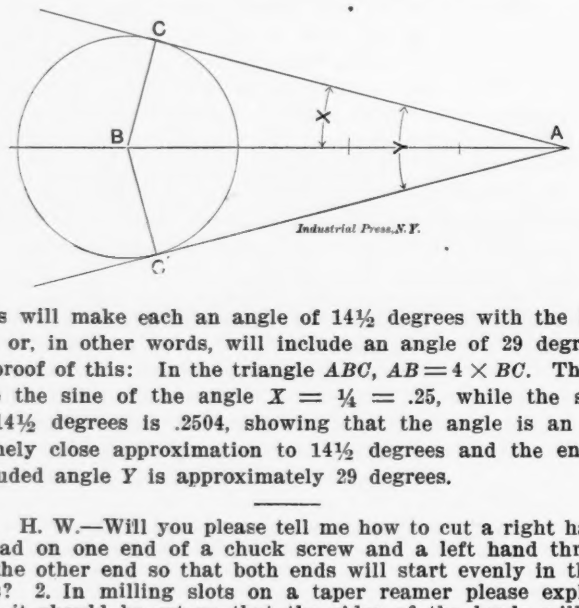
2. W. S. C.—Will you please tell me the angle of the sides of an Acme standard screw thread and explain how it can be laid out for making the thread cutting tool?

A.—The angle included by the sides of an Acme standard thread is 29 degrees. To lay out this angle, set the spacers to any convenient length and lay off four spaces on a straight line, as *AB*. At the end of the fourth space draw a circle having a radius equal to one of the spaces. From the starting point, *A*, draw two lines tangent to this circle and these



lines will make each an angle of 14½ degrees with the line *AB*, or, in other words, will include an angle of 29 degrees. In proof of this: In the triangle *ABC*, $AB = 4 \times BC$. Therefore the sine of the angle $X = \frac{1}{4} = .25$, while the sine of 14½ degrees is .2504, showing that the angle is an extremely close approximation to 14½ degrees and the entire included angle *Y* is approximately 29 degrees.

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3. H. W.—Will you please tell me how to cut a right hand thread on one end of a chuck screw and a left hand thread on the other end so that both ends will start evenly in their nuts? 2. In milling slots on a taper reamer please explain how it should be set so that the sides of the lands will be parallel?

Answered by J. T. Giddings, East Providence, R. I.

A.—Scribe a line on the blank parallel with the axis and mark each end on this line where it is desired that the screw should start. Having the lathe geared up for the required lead, take up the backlash as by pulling the belt by hand. Suppose, first, that we are cutting a V-thread, right hand. Set the tool or work so that the point of the tool crosses or intersects the starting point on the scribed line, then, after cutting the right hand thread, shift the tumbler gears for reversing the direction of feed, turn the screw end for end in the lathe and, feeding toward the tailstock, set the tool so that it will cross the starting point at the other end of the screw. If this is accurately done it is obvious that both threads will start on a line parallel with the axis as required. If a square threaded screw is to be cut the leading side of the tool may be set to cross the starting point for the right hand thread and the following side should cross the mark for the left hand thread. If the stock from which the screws are made is long enough so that both screws may be cut without reversing the piece end for end in the lathe, the leading side of the tool may in both cases cross the starting points, provided the right hand thread is the one nearest to the tailstock of the lathe.

The nuts may be threaded in a similar manner. When threading the left hand nut in the lathe it may be conveniently done as follows: Have the inside thread tool bent around in the opposite way to that in which it is usually used and cut the thread with the lathe spindle running backward, the lathe carriage feeding toward the headstock. Then for both right and left-hand nuts the leading side of the tool may cross the starting points, and for the left-hand nut the tool can be seen when starting its chip.

2. Having decided upon the number of flutes, find the length of chords for circles for both the large and small diameters of the taper. This may be conveniently done by reference to the data sheet furnished with the Engineering Edition of MACHINERY in Feb., 1903. which gives the length of chords, for a diameter of 1, for all divisions of a circle up to 100. Multiply the values given in the table by the diameters of the large and small ends respectively and thus obtain the length of chords at each end. From these results subtract the required width of land and this will give the width of the groove in the reamer at the large and small diameters respectively. Then cut the groove in the small end nearly to the required width for a short distance, lower the table and move the large diameter of the reamer under the cutter and make a groove of nearly the required width for a short distance on this end. Then set the bottom of both grooves at the same height, by moving the spiral head through an angle. (Assuming the reamer to be held in a chuck in the spiral head or in centers on a special fixture which goes in the spiral head for milling tapers.)

The required angle could be obtained either by surface gage, the adjustable dial for knee screw, or it may be calculated as follows: Obtain the difference in height of the grooves, the axis of the reamer being horizontal, by means of the dial, then divide the difference by the length of the taper. For example: Suppose the difference in height is ¼ inch in a length of 6 inches. $.25 \div 6 = .04166$, and this is the tangent of the angle required. By means of a table of natural tangents we can then find the angle which, in this case, is 2 degrees and 23 minutes or approximately 2 1-3 degrees, which is the amount that the spiral head should be raised.

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4. E. E. E.—I should appreciate your best receipt for bluing steel. The steel has a nice finish and is not hardened. I want to get a nice blue for color.

A.—We do not know of any better way than the usual one of heating in sand or charcoal. The following description of the process is as clear as any that we have seen. It is taken from the instruction papers on shop practice issued by the International Correspondence Schools, Scranton, Pa., which contain many similar items of value to the shop man. "Polished work made of iron or steel may be given a beautiful blue color by heating it in hot sand, in wood ashes, or in pulverized charcoal. The substance in which the article is to be blued may be put into an iron kettle that is placed over a fire. The substance must be constantly stirred while it is being heated in order that the whole may be brought to an even temperature. The article or articles to be blued must be absolutely free from grease if an even color is desired. They may be placed in a wire basket or may be suspended by wires and then immersed in the heated substance until the desired color is obtained. A light blue color can be obtained by heating in sand or in wood ashes, but a dark blue color requires the article to be heated in pulverized charcoal. The brightness of the color depends largely on the finish—the higher the polish the more brilliant the color which will be obtained. The substance in which the heating is done should be just hot enough to char a dry pine stick. By this manner of bluing, a piece of work having thick and thin parts can be given an even color all over."

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5. J. R. writes: Will you kindly inform me how to galvanize in an inexpensive way? I wish to galvanize round or flat wire and have it come out clean when finished.

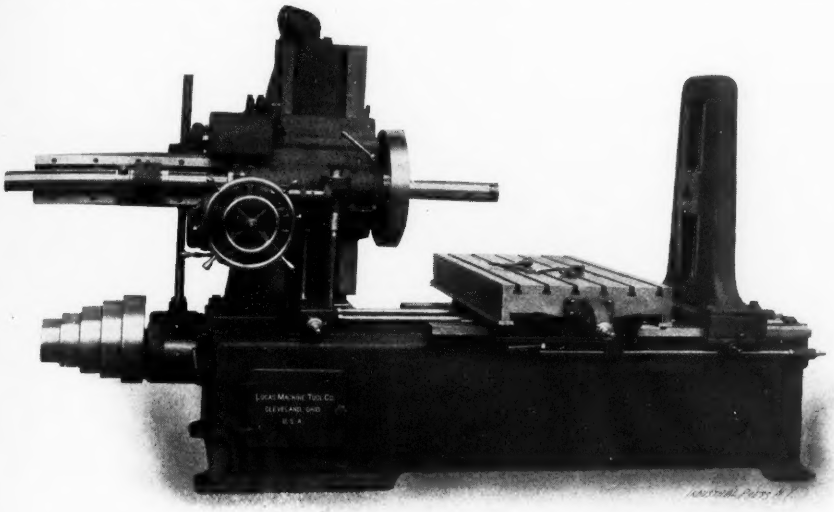
A.—We refer this to our readers for reply.

NEW TOOLS OF THE MONTH.

A RECORD OF NEW TOOLS AND APPLIANCES FOR MACHINE SHOP USE.

HORIZONTAL BORING, DRILLING AND MILLING MACHINE.

The "precision" horizontal boring machine which has just been brought out by the Lucas Machine Tool Co., Cleveland, Ohio, is designed with a special view to accuracy and permanence of alignment, the lack of which has been the principal objection to the knee type of machine. These points are attained by making the spindle adjustable vertically instead of the table, thus moving the constant instead of the variable



Horizontal Boring, Drilling and Milling Machine.

load. The advantages of this construction will be apparent. This construction permits of the use of a deep box bed carrying a table at a fixed height, this bed being much better able to resist the disturbing forces due to the cut and the weight of the work than the overhanging knee supported on screws.

To further insure against flexure, the bed is designed to rest on three points. Special attention has also been paid in the design, to arrange so that all operations can be carried on within range of the operator. The head is counterbalanced and is provided with a power elevating device as well as hand adjustment. The spindle is driven by an internal gear of large diameter and is powerfully back-geared. It is provided with both quick and slow hand motions which can be obtained instantly without throwing in any clutches or friction devices. The spindle may be fed 48 inches by two settings of 24 inches each.

The outer support for the boring bar is geared to raise or lower with the spindle, connection being made by a rod under the saddle, and an adjustment being provided whereby it can be corrected from time to time should it be required. The back rest is provided with means whereby it can be conveniently adjusted to any point along the bed and is made to be readily removed, when not required, without disturbing any of the working parts.

The gear feed box is provided on the head and is equipped with a reversing mechanism. The motion from this feed box can be readily converted to feed the spindle longitudinally, the table transversely, and the head vertically, the latter two feeds being milling feeds. The table is provided with automatic cross feed of 34 inches. The application of the cross feed to the table and the vertical feed to the head adapts this machine to a large variety of milling work. The elevating screw for the head and the table cross-feed screw have dials reading to thousandths.

The table is 30 x 48 inches, allowing a maximum distance from its top to the center of the bar of 26 inches and a distance from the spindle to the backrest of 5 feet, 6 inches. The machine is belt driven by means of a 3½-inch belt running on a five-step cone.

THE "HAMILTON" ENGINE LATHE WITH UNIVERSAL SCREW-CUTTING ARRANGEMENT.

The Hamilton Machine Tool Co., Hamilton, Ohio, have recently made extensive improvements in their engine lathes and are now placing on the market a new line of these machines in sizes from 14 to 28 inch swing and any length of bed. The headstock and tailstock, as well as the carriage and apron, have all received careful attention and have been redesigned and constructed to meet the requirements of the most advanced shop practice. The cross feed screws have micrometer adjustment and the tailstock spindle is graduated in inches for convenience in drilling. The apron mechanism is so arranged that it is impossible for the leadscrew and feed rod to be engaged at the same time, thus preventing breakages from this source. The longitudinal feed is powerfully friction driven, and all feeds are reversible from the apron. The leadscrew is used only for screw cutting, the turning feed being driven from a separate rod, and is not, therefore, liable to excessive wear.

The leading new feature of these lathes is the universal screw-cutting and feeding arrangement—an improved system of mounted gearing—giving a full range of screw pitches or feeds without removing a single gear, enabling the operator to change from one feed or thread to another almost instantly. This mechanism is illustrated in detail in Fig. 2 and is shown

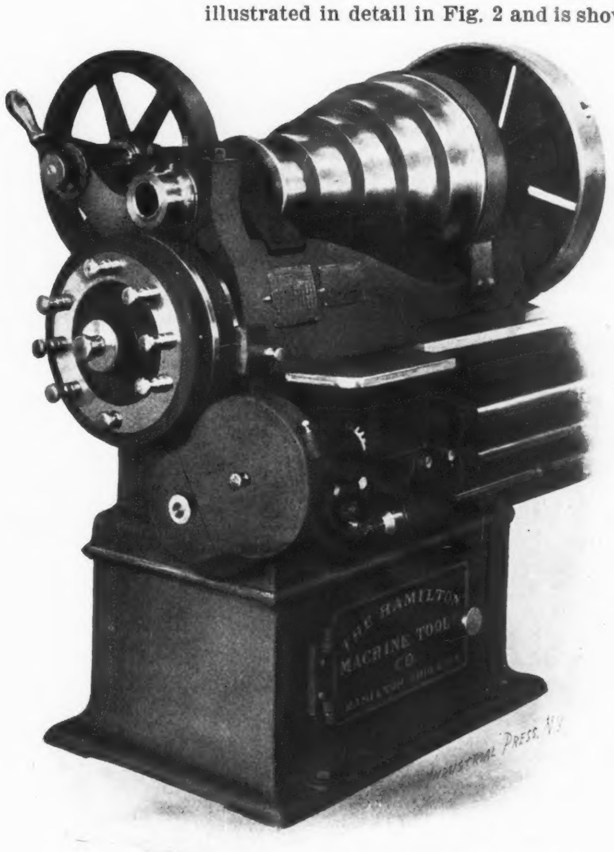


Fig. 1. Screw-cutting Arrangement of "Hamilton" Lathes.

as applied to the 26-inch lathe in the half-tone, Fig. 1. It is not an attachment in the strict sense of the word but is in reality an integral part of the lathe. By its use any one of 48 different feeds or screw pitches are made available in but a few seconds.

As will be seen in the line drawing, the spindle gear *B* transmits the motion through the compounding gears *C* (of which only two are engaged at the same time), through the

center pin E, to the driving gears F; these drive the lower clutch change gear G and connecting clutch gear L, which transmit the motion through the intermediate gear M to the leadscrew gear P. The circular gear box J may be rotated so as to bring any of the eight mounted clutch change gears G in mesh with the intermediate gear M. The reversing mechanism R is controlled from the front of the lathe apron by means of the reversing rod V. S is the leadscrew and T is the feed rod. The mounted clutch gears G are entirely independent of each other and are arranged so that only the one in use can be engaged. No adjustments are necessary in changing from one thread or feed to another.

leadscrew, 16 additional threads, from 2 to 7 may be obtained, and by using the 20-tooth slip gear, still another 16 threads from ½ to 1¾ are obtained, thus affording a total range of 48 threads or feeds. On this size of lathe the ratio between the feeds and threads is 8 to 1, and on the other sizes it is in proportion. To secure any desired feed it is only necessary to reduce it to the corresponding thread, by dividing by the ratio as given in the index, and set up the machine accordingly. These lathes are designated by the manufacturers as their style "A," in order to distinguish them from the regular pattern or style "B" lathes, having the ordinary loose change gears for screw cutting.

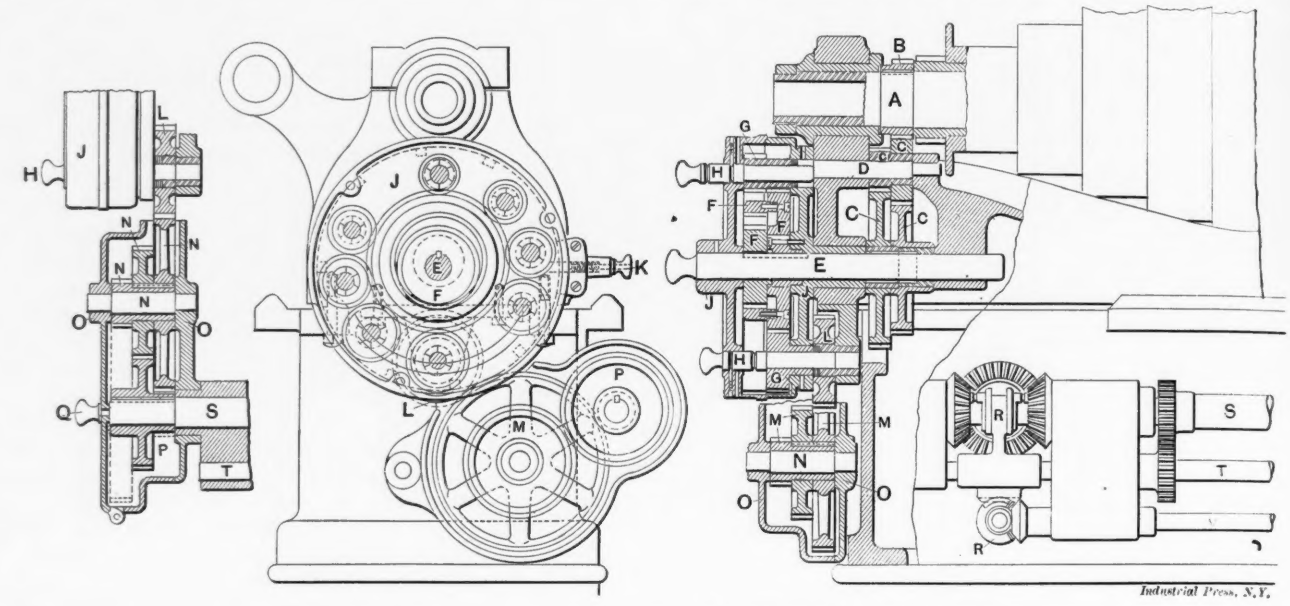


Fig. 2. Detail of Screw-cutting Arrangement used on "Hamilton," Style "A" Lathes.

Fig. 3 shows a *facsimile* of the index plate used on this, the 26-inch lathe. The words "in" and "out" in the column under "center pin" refer to the position of the sliding shaft E, in the center of the circular gear box. Under "screw" is given the required leadscrew change gear; three of these gears are provided, and they can be instantly slipped on or off as required. The "box numbers" are stamped on the circumference of the circular gear box and designate the different mounted clutch change gears G; the box should be rotated until the "box number" called for is opposite the pointer, when it is instantly secured in position by a spring locking pin; this brings the required "box" gear into mesh with the connecting clutch gear L, to which it is connected by simply pushing in the handle or knob H with which each "box"

THE HAMILTON MACHINE TOOL CO
HAMILTON, OHIO, U. S. A

Center Pin	Screw	BOX NUMBERS. 1	2	3	4	5	6	7	8
		THREADS PER INCH.							
In	20	½	9/16	⅝	11/16	23/32	¾	13/16	⅞
Out	20	1	1⅛	1¼	1⅜	1 7/16	1½	1⅝	1¾
In	50	2	2¼	2½	2¾	2⅞	3	3¼	3½
Out	50	4	4½	5	5½	5¾	6	6½	7
In	80	8	9	10	11	11½	12	13	14
Out	80	16	18	20	22	23	24	26	28

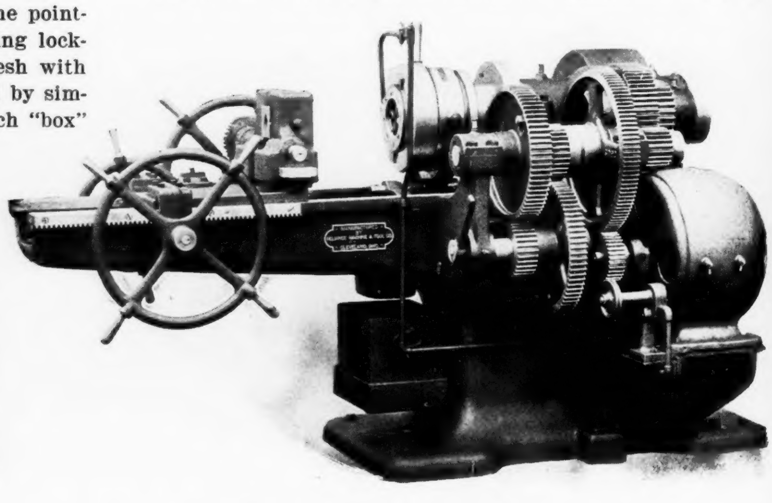
PATENTED OCT. 15, 1901. OTHER PAT. PENDING.
FEEDS—8 TIMES THREADS.

Fig. 3. Index Plate of 26-inch "Hamilton" Lathe.

gear is provided. The knob on the gear in mesh is always at the lowest point of the circular gear box, and the arrangement is such that it is impossible to push in the wrong knob, thus preventing any error from this source. Referring to the index plate, it will be noted that if we employ the 80-tooth gear on the leadscrew, 16 different threads from 8 to 28 per inch may be cut without removing a single gear, the changes being made while the lathe is in motion, by simply rotating the circular box and setting the center pin as called for in the index. By placing the 50-tooth slip gear on the

A NEW ELECTRICALLY-OPERATED BOLT CUTTER.

The Reliance Machine and Tool Co., Cleveland, Ohio, have just brought out a new bolt cutting machine which is a decided departure from what has hitherto been their standard type of machine. This is the 3-inch bolt cutter that is shown in the accompanying photograph, and it is equipped with a Crocker-Wheeler motor and controller. A new and distinctive feature is found in the method of driving the spindle or shaft, the driving gear of which is located centrally be-



Rear View of Electrically-driven Bolt Cutter.

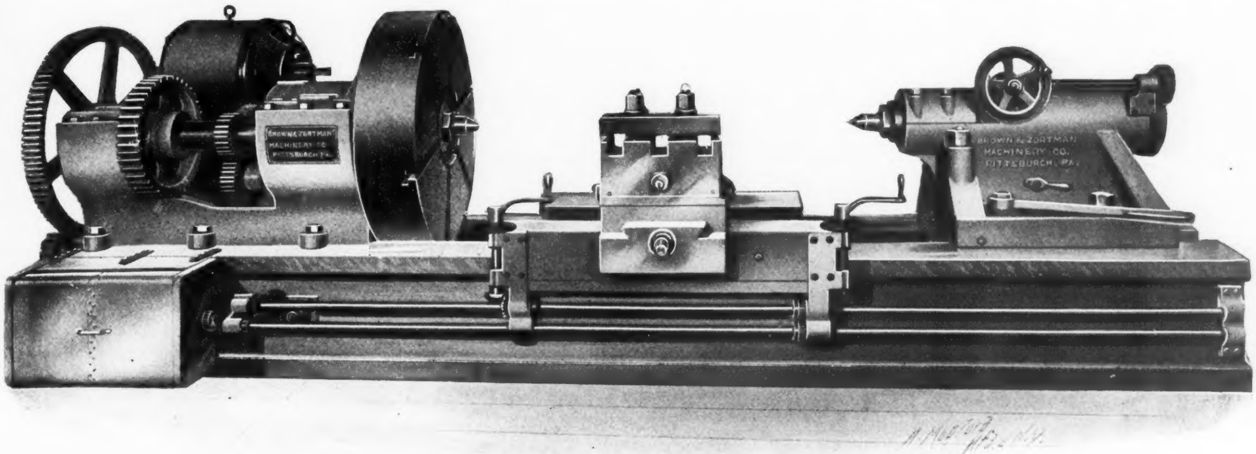
tween the bearings of the spindle instead of being at the extreme end thereof. A system of compound gearing makes it possible to obtain greater power without having an unduly large driving gear. This method of driving the head spindle eliminates all torsion and produces a smoother and more rapid cut without chatter.

The oil and chips which work through the hollow spindle are no longer a cause of trouble by falling upon the belt and pulley. The working parts are all easily accessible and the floor space has been reduced by the compact design of the

machine. In the belt-driven machines, a four-step cone pulley replaces the gear that is shown in the cut meshing with the motor pinion.

A NEW 42-INCH FORGE LATHE.

The Brown & Zortman Machinery Co., Pittsburg, Pa., have just placed on the market the new 42-inch forge lathe that is illustrated in the accompanying half-tone. This lathe is arranged to be driven by a 25-horse power variable speed motor or by a 4-inch belt running on a five-step cone pulley.



Brown & Zortman 42-inch Forge Lathe.

Five speeds are thus available and by changing a gear on the end of the motor or cone shaft, five more speeds are obtained. The gearing is in the ratio of 1 to 84, and terminates in a broad internal gear in the faceplate by which the spindle is driven. A large and a small cathead are provided which are fastened to the faceplate and used in lieu of dogs for driving the work.

The tailstock is clamped to the bed by six binding bolts and is also provided with a latch which drops into a slot in the bed and thus keeps the tailstock from sliding back. A hand wheel and gear arrangement is provided to facilitate the movement of the tailspindle in and out of the tailstock.

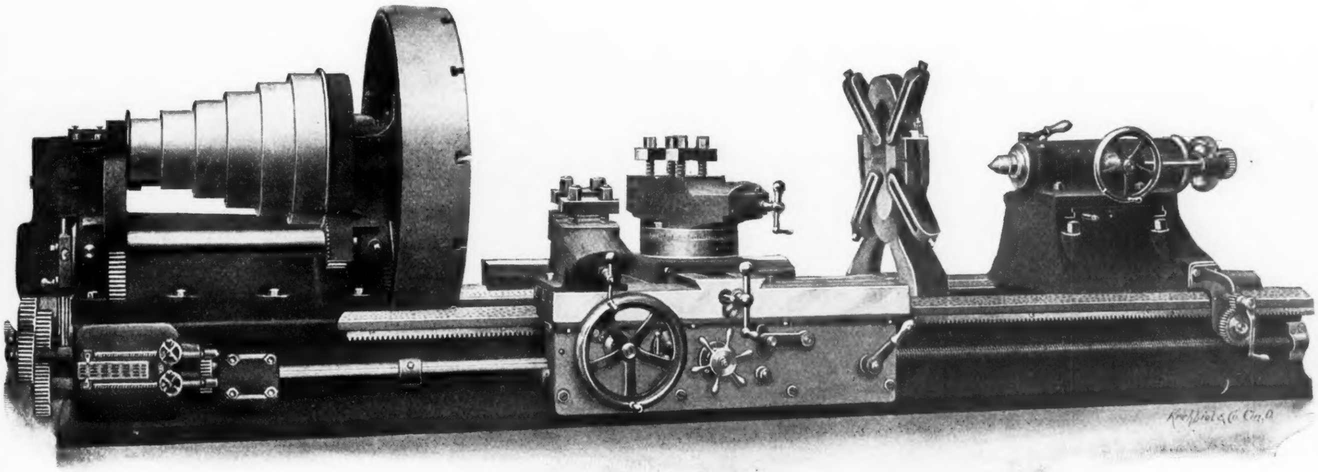
The carriage has no hand movement along the bed but has three feeds, available by lever at the apron. These feeds can be changed from one to the other instantly while the machine is in operation. The feeds are .189, .354, .664 inch, and then by changing the gears .134, .251 and .469 inch per revolution of the spindle. Quick movement is furnished to the carriage when it is to be moved a considerable distance, and at other times the coarse feed is available. The feed is driven by gears in the headstock which in turn drive a screw, inside of the bed, running in a long, solid, bronze nut which is fastened to the carriage. This screw is supported in bearings planed into every cross tie in the bed and the thrust in either direction is taken upon large ball bearings. The carriage is furnished with an upper block that has three grooves for securing tools, $2\frac{1}{2} \times 3$ inches, and which allows of a hand movement of the tool longitudinally. When the variable speed motor is used the carriage is provided with a controller lever by which any speed forward or backward can be obtained at once.

The lathe, when mounted upon a 20-foot bed, has a capacity of 10 feet between centers and weighs about 38,000 pounds. Any length of bed may be furnished, each additional 2 feet of length adding about 1,450 pounds to the total weight.

SIXTY-INCH "AMERICAN" SCREW-CUTTING LATHE.

The American Tool Works Co., Cincinnati, O., have just brought out the new 60-inch screw-cutting lathe illustrated in the accompanying half-tone. This tool is equipped with improved rapid change gear mechanism which greatly increases its capabilities as a rapid handler of heavy work. This mechanism is located on the head end of the bed and consists of a clutch device, of new design, through which seven changes for feeding and screw cutting are rapidly available without the removal of a gear. Then, by changing a single gear on the stud, seven additional changes are provided, the quadrant being so designed as to obviate the readjusting of the entire train of gears to each new change gear. Nine change gears are ordinarily furnished, thus providing a total of 63 changes of threads and feeds. Each of these changes is indicated on the index plate located on the front of the gear box. By the simple movement of a hand wheel, a pointer is brought directly above the desired thread or feed. This will indicate the number of the change gear that is to be placed on the stud and also automatically arrange the gears in the gear box for cutting any thread or feed desired. The range of threads is from one in eight inches to 16 per inch.

The lathe can be arranged for left-hand screw cutting by means of a tumbler reverse plate which is mounted on the end of the headstock, so that it is not necessary to interpose



American Tool Works Co.'s 60-inch Screw-cutting Lathe.

an idler gear as formerly and no gears are ever disarranged by this method.

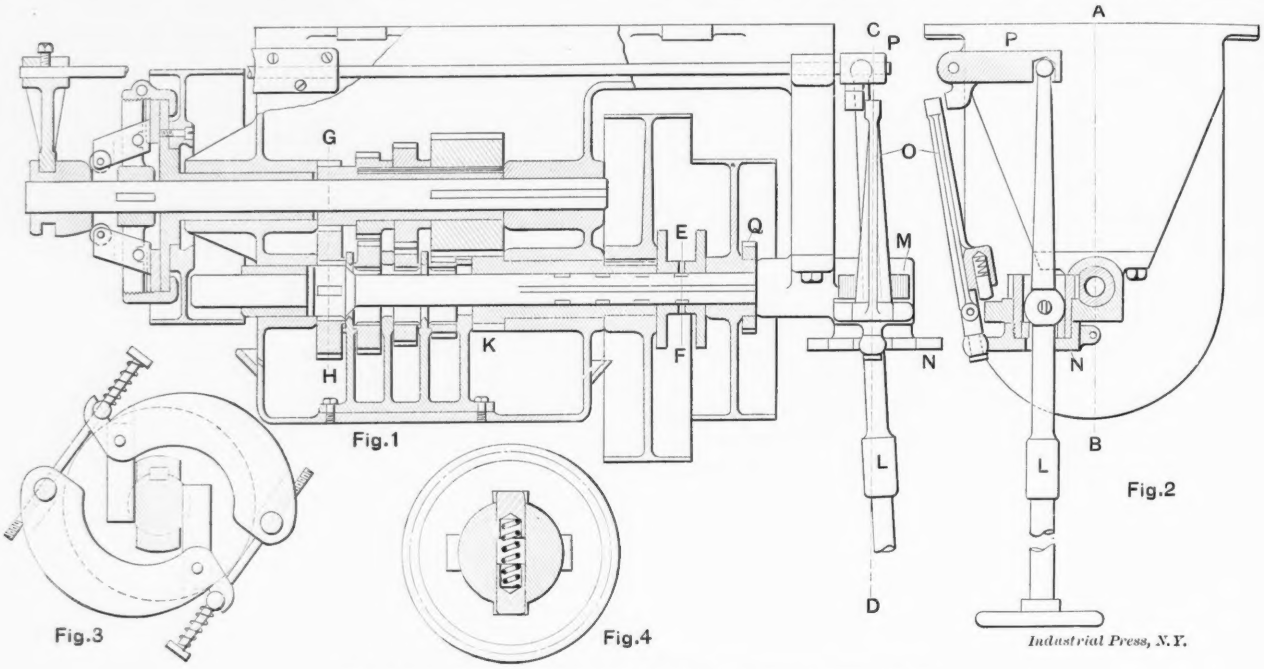
The bed is of drop V pattern, of such construction as to secure the greatest rigidity. The headstock is massive and the driving cone is mounted on a spindle of its own, entirely independent of the main spindle, and is powerfully geared. The carriage is very heavy, especially in the bridge, due to the drop V bed, and has double apron extending its full length. The compound rest is fitted with taper gibs and provided with power cross and angular feeds.

THE "SCHELLENBACH" VARIABLE SPEED PLANER COUNTERSHAFT.

While much has recently been accomplished in the development of the variable speed countershaft for use with machine tools in general, a countershaft for the exclusive use on planers, combining with variable speed drives a constant return and provision for elevating the cross rail, has, up to the present we believe, been lacking. The demand for such a countershaft has been met by the "Schellenbach" variable speed countershaft, illustrated by the accompanying drawings and half-tone photograph, which is the product of the National Machine Tool Co., Cincinnati, Ohio. This countershaft provides for four cutting speeds, ranging from 20 to 50 feet per minute and a constant return speed of 70 feet per minute.

Referring to the illustrations, the pulley shown at the left takes its power from the main line as in the ordinary countershaft. It is operated with the usual sliding bush and fork, engaged and disengaged by the shipper rod which passes entirely across the main frame and connects with the lever, at the lower end of which will be seen the handwheel by which it is moved back and forth. The method for obtaining the changes of speed will be understood by reference to the drawings, Figs. 1 to 4. The upper cone of gears is made of forged steel and is fitted as a unit for convenience in assembling. The largest gear of the upper cone meshes with a sleeve pinion, *K*, which passes through and takes its bearing in the casing. It has keyed to it the pulley which drives the return stroke of the planer platen. Thus it will be seen that the return speed is always constant and is not influenced by the four gears, with large bore, which rest in receptacles normally out of mesh with their mates above. These gears are keyseated, as is shown in Fig. 4, which is a section on the line *G H*, and receive the flat tool steel keys which are fitted into a slot cut through the enlargement of the lower shaft. These keys oppose each other with the aid of springs which are side by side. The casting, which supports the lower cone of gears, by their hubs which rest in counterbored receptacles, is bored to fit the enlargement of the lower shaft and serves to depress the keys as the enlarged portion containing them passes through. The lower shaft is splined to receive the smaller pulley which controls the cutting speeds.

Cut into the shaft are notches spaced to correspond with the gears which make the changes. The two pulleys, as shown in Fig. 1, are separated by a flange casting the inside of which on the line *E F*. The casting referred to is also splined to turn with the lower shaft and contains latches which mesh into the notches above referred to. Fig. 3, which is a section on *E F*, shows this centrifugal lock, which is a simple and sure means of making it impossible to mesh the gears when running at a high speed. The lever *L* is ball-seated into the gear *M*, and serves the purpose of revolving this gear as well as operating the friction pulley as before mentioned. The gear *M* has a cam *N* attached to it and this cam operates the lever *O* and forms a locking device which makes it necessary to release the friction pulley before a change of speed can be made, and if such change is only partly made the friction pulley cannot be connected. A glance at Figs. 1 and 2 will readily show how this is accomplished by means of the parts *N*, *O* and *P*.



Figs. 1 to 4. Details of "Schellenbach" Variable Speed Countershaft.

The pulley *R*, in Fig. 5, is used for elevating the rail and is driven through a short shaft upon which is a gear that meshes with the gear *Q*, Fig. 1. This elevating pulley shaft may be extended to suit conditions and a regular hanger used to support it. The device throughout is provided with thorough facilities for oiling and a drip pan is cast on either end of the gear casing under the shafts to catch the oil and return it inside of the casing. The gears may run in an oil bath if preferred.

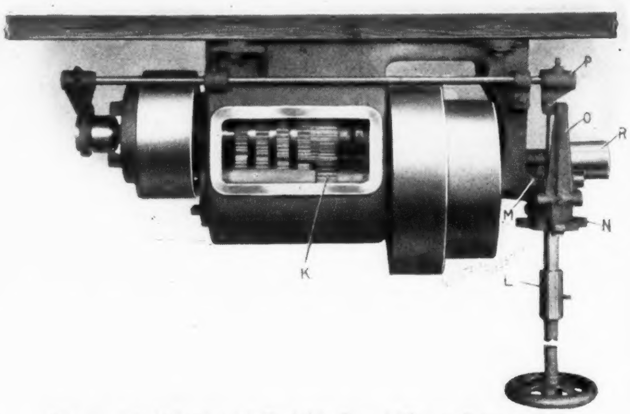
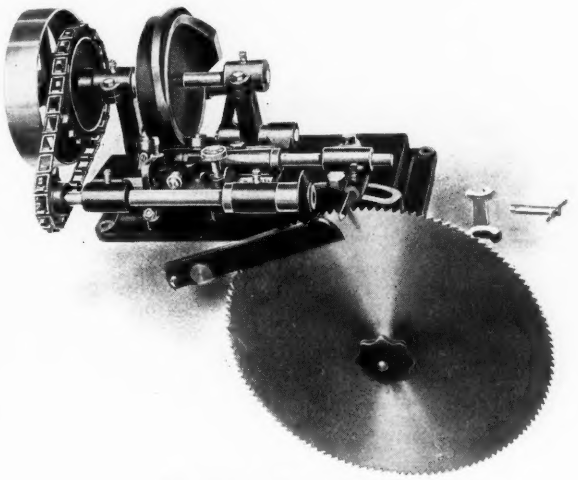


Fig. 5. "Schellenbach" Variable Speed Planer Countershaft.

When desired the friction driving pulley may be omitted and a coupling provided to receive a motor shaft, thus making a simple and direct method for using a constant speed motor.

AUTOMATIC SAW FILING MACHINE.

The accompanying cut illustrates a machine that is designed for truing up and filing circular, band and hand saws by power and thus obviating the tedious hand work ordinarily required for this purpose. The machine uses a rotary file about $2\frac{1}{4}$ inches in diameter, having a cross section suitable for the work. Two forms of file are usually required, the one for rip saws having an angle of 50 degrees, and that for cut-off saws having an angle of 60 degrees. The file is carried by a rocker arm, and a spacing gage, provided with hardened steel finger and adapted to drop into the tooth space, is also carried by a slide on the rocker arm. A cam motion is arranged to automatically lift the file clear of the teeth, move the gage forward, drop it into a tooth space, bring back the file to normal position and then drop it into the next tooth space. This space gage is normally held firmly into the tooth space by spring pressure and holds the saw against any longitudinal movement, while the file may be readily adjusted toward one side or the other of the tooth space if the latter is uneven. The guide clamp is provided to hold the saw blade and at the same time permit it to be readily slipped through.



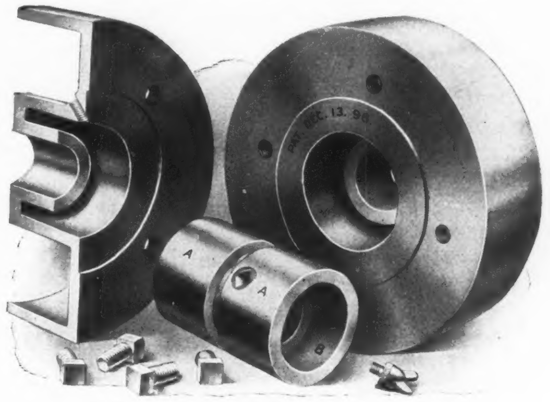
Automatic Saw Filing Machine.

To control the depth of cut of file an adjustable screw is provided in the rocker arm, allowing the latter to drop only to a predetermined distance and hence allowing the file to cut only to the desired depth. These two features, the spacing gage and the depth gage, make it possible to true up unevenly-filed or toothed saws, and once a saw is true it can be filed without further attention. Means are provided for setting the saw at any unusual angle of hook and at any bevel of teeth up to 30 degrees. Adjustment is also provided for varying the position of the file with reference to the spacing gage while the machine is in operation. This machine is adapted, by use of an interchangeable saw-carrier, for filing band saws and for hand saws. It has a capacity for filing circular saws up to 22 inches in diameter and $\frac{1}{2}$-inch teeth, band saws up to $\frac{1}{2}$-inch teeth and $1\frac{1}{2}$-inch width of face. It will also file as large as 1-inch teeth on the points, when the gullet can be filed out at a separate operation. This machine is the product of the Rotary File & Machine Co., Brooklyn, N. Y.

THE "NELSON" LOOSE PULLEY.

Of all appliances used in connection with the running parts of machinery, none have been the source of greater annoyances than the loose pulley. On this account numerous devices have been produced to insure proper lubrication and prevent the pulley from sticking to the shaft. Most of these consist of a network of oil grooves, a multitude of drilled holes or the use of a bushing of wood, babbitt or other anti-friction material. The trouble with a great many of these devices is the lack of sufficient bearing surface for the hub of the pulley. While capillary attraction between the shaft and the sides of the bore of the pulley would naturally tend to preserve a thin film of oil entirely around the shaft, the load on the pulley produces so great a pressure per square inch of bearing surface that the film of oil is forced out and metal-to-metal contact ensues and causes trouble.

A loose pulley that is somewhat out of the ordinary construction and in which the above trouble has been obviated is the "Nelson" loose pulley, which is illustrated herewith. In this case the pulley does not run directly on the shaft but upon a sleeve or bushing, *A*, which is firmly clamped to the shaft by headless setscrews. This arrangement furnishes a large bearing surface for the hub of the pulley and thus reduces the pressure per square inch to such an extent that the



Details of the "Nelson" Loose Pulley.

film of oil continually surrounds the sleeve and permits the pulley to run upon the oil without any actual contact with the sleeve. Oil is held in an oil chamber formed in the bushing and from this reservoir it is thrown by the action of centrifugal force onto the bearing surface. The great advantage of this method of lubrication is, that as the speed of the pulley increases, and more lubricant is demanded, the centrifugal force likewise increases, thus adequately suiting the supply to the demand.

The pulley is made in halves which fit over the bushing and their hubs, form a guard that is proof against dirt or dust from without and the escape of oil from within. A continual supply of clean oil is thus insured, and when once the reservoir has been filled the pulley may be run indefinitely without attention. To replenish the oil supply it is necessary only to remove a small thumb screw and fill the oil chamber from an oil can. These pulleys have been thoroughly tested for a period extending over five years and, having proved satisfactory, are now being placed upon the market by the Wilmarth & Morman Co., Grand Rapids, Mich.

UNIVERSAL DRILL PRESS JIG.

In view of the difficulty experienced in holding in an ordinary vise, cylindrical pieces such as pulleys, journals, cones, cams, etc., the Bayldon Machine & Tool Co., Jersey City, N. J., designed and constructed the drilling attachment here illustrated and so successful has it proved that they have

Universal Drill Press Jig.

now placed it upon the market as one of their regular products. This tool consists of an angle plate, upon the vertical side of which are located two V-blocks which may be adjusted in a vertical direction so as to stand at any required distance apart. On the horizontal base of the angle plate is a sliding clamp jaw which can be regulated to suit both the diameter and height of the work to be drilled.

Above the V-blocks is located a bushing holder which may

be moved in and out to accommodate varying diameters of work but always remains in line with the center of the V-blocks. This holder is for carrying steel bushings that act as a guide for the cutting tool, which may be a rose reamer, an ordinary twist drill, a four-lipped drill or a boring bar. Bushings can be furnished for any diameter of drill or bar up to 3½ inches in diameter. The capacity of this tool ranges from pieces 7 inches in diameter and 6½ in length, down to those 1½ in diameter and 1 inch long.

A NEW MILLING MACHINE FOR HEAVY WORK.

The Henry Hess Machine Co., Philadelphia, Pa., have just brought out a new type of slab milling machine that is especially adapted to all kinds of heavy work where it is desired to produce flat surfaces quickly and cheaply. This machine is capable of taking a cut equal to the greatest width between the housings, 30 inches, and carries cutters up to 15 inches in diameter. The platen, as ordinarily furnished, has a working capacity of 8 feet, and may be increased, if necessary, by increments of 2 feet. The cutter is driven by a worm of steep pitch which is, in turn, driven from a two-speed overhead countershaft with cone pulley. The cutter itself terminates at the driving end in a large flange, which is bolted to a corresponding flange upon the driving arbor. The drive is therefore from a diameter equal to or larger than the diameter of the cutter employed.

The outer end of the cutter is supported in a bracket mounted upon the same cross rail that carries the driving head, and when two pieces are being milled side by side an intermediate support is introduced between the two pieces of work. The cross rail may be raised or lowered by power and has micrometer adjustment for depth of cut. Provision is made for driving the spindle at eight speeds, from a minimum of 6 revolutions per minute to a maximum of 36. The platen has both hand and power feed, and a quick return by power. The rate of feed is controlled by a small handwheel, which is placed near the operator, and may be varied from .5 inch to 30 inches per minute, twelve changes being provided for. The net weight of this machine is about 52,000 pounds.

* * *

NEW TRADE LITERATURE.

The Ray Automatic Machine Co., Cleveland, O. Circulars treating of the "Vulcan" steel annealing box and "Vulcan" putty for annealing, with directions for using. Also folder treating of the manufacture of automobile parts such as hoods, fenders, radiators, tanks, mufflers, etc., with illustrations of same.

The Webster & Perks Tool Co., Springfield, O. Circular of grinding and polishing machinery. The 1-inch bench grinder, the 1¼-inch self-oiling bench grinder, the improved No. 1 and No. 2 self-oiling, buffing and polishing lathes, are shown. Also a 1-inch grinder on a pedestal.

Wm. Pilton, Hamilton, O. Descriptive circular of parallel ruler attachments, which may be attached to any form of drawing boards or tables, for office, school or home use. Also circulars describing an instantly adjusted drawing table, and a draftsman's new handy reference table.

Hammacher, Schlemmer & Co., New York. Catalogues Nos. 185, 187, 188 and 190. These are supplementary lists of the various classes of goods catalogued. The first of these treats of hand screws, bench screws, clamps, etc.; the second of wood carvers' tools and accessories; the third, of miter boxes, trimmers, etc.; and the last, of files and rasps.

The Ingersoll-Sergeant Drill Co., 26 Cortlandt Street, New York. New drill catalogue No. 43, the first of a series of catalogues which will illustrate and describe in very complete form all classes of Ingersoll-Sergeant machinery. The cuts and descriptive matter are nearly all new and the catalogue itself is an unusually handsome product.

The Loop-Lock Machine Co., Waltham, Mass. Price lists of the No. 2 bench and No. 3 special milling machines and attachments, and of No. 3 bench lathes and attachments. Also illustrated circulars of No. 2 bench milling machine, No. 3 automatic internal grinding machine and of No. 3 bench lathe, new model, and attachments for same.

The Etna Manufacturing Co., No. 253 Broadway, New York. Special illustrated circular describing their new clock spring-tempered back, hack saw blades. They state that the blades are manufactured by their new process, whereby the tooth edge only is left hard, while the back is drawn to a clock spring temper, permitting the saw to bend without kinking or breaking readily, and thereby giving the user full efficiency until the teeth are worn out.

The Peerless Rubber Mfg. Co., 16 Warren Street, New York. Catalogue No. 58 of "Peerless" spiral piston and valve rod packings. "Rainbow" packing is described, which is especially adapted for very high pressure, being vulcanized in a higher degree of heat than it ever comes in contact with in a joint. The "Eclipse" sectional rainbow gasket is also treated, as well as the different styles of packings for various purposes, and seamless rubber belting, steam hose, etc. This catalogue will be sent to any one upon application.

The Berlin Construction Co., Berlin, Conn. Catalogue 1903 giving 40 illustrations of steel-frame construction work done by this company. This includes machine rooms, factories, foundries, bridges, etc., and the cuts give an excellent idea of the great variety and good quality of the work done. A partial list of the company's customers also appears. The company have a complete modern structural steel plant, and their shops are operated throughout by electricity and compressed air. The branch offices are at New York, Boston, and Newark.

The North Penn Iron Co., North Penn Junction, Philadelphia, Pa. Bulletin "W" No. 705, treating of the steam locomotive cranes manufactured by this company. These cranes are useful in yards, as any irregular area can be covered with them, and they can be used as a locomotive for moving freight cars for transporting heavy work from one building to another. These steam cranes are especially useful in plants where electric power is not available. An illustration shows a 10-ton crane, with half cab or roof. Full cab can be furnished if desired. The cranes are made for standard track gage of 4 feet 8½ inches.

Pratt & Whitney Co., Hartford, Conn. Standard 6 x 9 booklet just issued of the company's bench lathe, 10-inch toolmakers' lathe, 13-inch engine lathe, and 14-inch gibbed carriage engine lathe. The book contains 67 pages and is fully illustrated with excellent halftone plates. The first thirty-seven pages are taken up with a description of the 7 x 32-inch bench lathe, described in detail and illustrations are given of more than thirty of the various attachments which may be furnished with the lathe, giving an adequate idea of the great diversity of work for which this machine is adapted. The 10-inch toolmakers' lathe is also carefully described, and illustrations are given showing the application of the collets and split step chucks to the spindle. Two views of the 14-inch lathe show the standard lathe, and the lathe with pan bed. A number of important attachments for this lathe are also shown. These include the relieving attachment for relieving straight, taper and spiral taps and milling cutters, draw-back collets, step chucks and closers and expanding arbors. While these lathes perhaps are not applicable to rough shop use, anyone who cares for good machines or who has to do accurate work will appreciate them.

MANUFACTURERS' NOTES.

The foundry and machine business formerly conducted by the Robert Poole & Son Co. has been merged into the Poole Engineering & Machine Co., and will be continued under this corporate name.

The Ray Automatic Machine Co., formerly at Cleveland, O., have removed to corner Front Street and First Avenue, Berea, O., where they have increased facilities for manufacturing their line of automatic nut machines, cold punched nuts, etc. They state that the rates of freight from Berea are the same as from Cleveland.

E. Horton & Son Co., Windsor Locks, Conn., have recently completed an addition to their works which triples their capacity. They have installed a number of special machines and discarded all the old tools, bringing their plant up to date in every respect. The Horton Co. build a complete line of chucks, including every kind made.

The Springfield Tap & Die Co., Springfield, Vermont, have incorporated a number of features in their product which adds to its value. Their patent relief ensures excellent results, and their improved method for threading does away with many of the inaccuracies which taps have heretofore been subject to. Their sizes are guaranteed to run uniform, which is a feature that every mechanic will appreciate.

The Brown & Zortman Machinery Co., Pittsburg, Pa., have opened an office and store room at the Bourse, Philadelphia, under the charge of R. G. English, where they will be glad to see all their Eastern friends. They will have constantly on the floor both Colburn boring and turning mills and Universal saw tables, as well as a full line of modern machine tools of standard manufacture.

The D. E. Whiton Machine Co., New London, Conn., have just completed a new foundry, 60 x 100, which will add greatly to their facilities. The building adjoins their works and is high and well lighted, and will be equipped with all the modern foundry appliances. They have also built a four-story L-shaped addition to their works, 80 x 85, extending along the railroad track and giving them unexcelled facilities for receiving and shipping goods.

The Abrasive Material Co., of Philadelphia, have made two more additions to their already extensive plant—another new kiln, and a recent installation of new machinery for making their pressed emery wheels. The present abrasive emery wheel is made by the vitrified process, and by reason of its fast, free cut has given great satisfaction in all classes of grinding. The makers, however, realize the need of special wheels for special purposes, and have decided to place on the market a pressed wheel that will, for its special work, equal those made by the vitrified process.

The Ingersoll-Sergeant Drill Co., 26 Cortlandt Street, New York, who have placed a line of pneumatic tools on the market, report immediate recognition of the excellence of the Haeseler "Axial Valve" hammers, upon comparative tests with other tools. Among the latest purchases of these tools are: Niles-Bement-Pond Co., Ramapo Iron Works, MacPherson Switch & Frog Co., Creswell & Waters Co., Warren Foundry and Machine Works, Chicago, Rock Island & Pacific R. R.; Brown Hoisting and Conveying Machine Co., Howard Iron Works, International Boiler Works Co.

Roth Bros. & Co., manufacturers of dynamos and motors, have recently moved to 27-29 So. Clinton Street, Chicago, Ill., where they have more than doubled their floor space and have added machinery for the more efficient handling of their work. They have fitted all their machines with individual motor drive. Some have the motor directly connected while others have single belts—the lathes for instance, which are driven by their electric countershafts, or motors with a back-geared shaft upon which is mounted the cone pulley. The controller, of the reversible style, is also hung from the ceiling and operated by a rod connecting with a splined shaft on the lathe, which rod is in turn operated by a handle which travels with the lathe carriage. Coarse changes of speed are obtained by shifting the belt, and intermediate speeds, through the controller.

The Standard Welding Co., Cleveland, O., inform us that a very interesting test has recently been made, at a large bicycle factory, of two bicycles—one built entirely of seamless tubing made by the Standard Welding Co., and the other, with ordinary seamless tubing. The wheels were put to test on a vibrating machine with the result that the bicycle of ordinary tubing went to pieces after a continuous run of only 36 hours, while the bicycle built with the "Standard" seamless tubing stood up over 72 hours, thereby demonstrating its strength to be twice as great as that of the cold-drawn tubing. The "Standard" tubing is made from stock of uniform thickness, and the welding, which is done by electricity, makes every section of the tube of equal strength, and the product much more uniform than is possible with the cold-drawn tubing.

Thos. H. Dallett & Co., Philadelphia, Pa., have lately been reorganized and incorporated as the Thos. H. Dallett Co., with officers as follows: President, Thos. H. Dallett; Vice-President and General Manager, Ernest C. Bliss; Secretary and Treasurer, E. C. Clay. W. H. Van Sickel, lately New York representative of the Under-Feed Stoker Co., of America, and formerly identified with the pneumatic tool industry, is Superintendent. The company will greatly extend and enlarge the capacity of their plant, located at York Street and Sedgley Avenue, and while continuing the manufacture of their well-known belt and electrically driven portable drills, deck planers, etc., will devote especial attention to the production of "Dallett" pneumatic tools. Their works are equipped with the latest and most improved machinery.